

EPA Contract No.: 68-S7-3002  
Work Assignment No.:038-RDRD-03H6  
Black & Veatch Project No. 47118.130

Intermediate (60%) Basis of Design/Design Criteria Report  
Revision: 0  
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## **APPENDIX H**

### **Intermediate Design Specifications**

## Section 02704 - PIPELINE PRESSURE AND LEAKAGE TESTING

### PART 1 - GENERAL

1-1. SCOPE. This section covers field hydrostatic pressure and leakage testing of all piping of the groundwater treatment system except sewer pipe for discharge piping and includes, but is not limited to the following: process piping and subsurface piping. The term "piping" shall be used in this section to refer to piping systems, pipelines, or sections thereof.

1-2. GENERAL REQUIREMENTS. The Contractor shall be present during testing and shall be notified of the time and place of testing at least 3 days prior to commencement of the work. All work shall be performed to the satisfaction of the Contractor.

1-2.01. Testing Schedule and Procedure. A testing schedule and test procedure shall be submitted to the Contractor for review and acceptance not less than 7 days prior to commencement of testing. The schedule shall indicate the proposed time and sequence of testing of the piping. The testing procedure shall establish the limits of the piping to be tested, the positions of all valves during testing, the locations of temporary bulkheads, and all procedures to be followed in performing the testing.

1-2.02. Water. Water for testing shall be furnished as stipulated in the temporary facilities section. Following completion of testing, the water shall be disposed of in a manner acceptable to the Contractor. Unless otherwise permitted by the Contractor, the water shall not be allowed to enter other parts of the pipeline or treatment system.

1-2.03. Compressed Air. All necessary equipment for the generation of clean compressed air for testing shall be furnished by the Subcontractor. Unless otherwise permitted by the Contractor, the compressed air shall not be allowed to enter other parts of the pipeline or treatment system.

### PART 2 - PRODUCTS

2-1. TEST EQUIPMENT. All necessary connections between the piping to be tested and the water and/or air source, together with pumping equipment, air flow meter, water meter, pressure gauges, and all other equipment, materials, and facilities required to perform the

specified tests, shall be provided. All required flanges, valves, bulkheads, bracing, blocking, and other sectionalizing devices shall also be provided. All temporary sectionalizing devices shall be removed upon completion of testing. Vents shall be provided in test bulkheads where necessary to expel air from the piping to be tested.

Test pressures shall be applied by means of a force pump (water) or compressor (air) sized to produce and maintain the required pressure without interruption during the test.

Water meters, air flow meters and pressure gauges shall be accurately calibrated and shall be subject to review and acceptance by the Contractor.

Permanent gauge connections shall be installed at each location where test gauges are connected to the piping during the required tests. Drilling and tapping of pipe walls will not be permitted. Upon completion of testing, each gauge connection shall be fitted with a removable plug or cap acceptable to the Contractor.

### PART 3 - EXECUTION

3-1. FILLING AND VENTING. Before filling the piping with water, care shall be taken to ensure that all air release valves and other venting devices are properly installed and in the open position. Hand-operated vent valves shall not be closed until an uninterrupted stream of water is flowing from each valve. The rate of filling the piping with water must not exceed the venting capacity of the installed air vent valves and devices.

3-2. BLOCKING AND BACKFILLING. Piping shall be adequately blocked, anchored, and supported before the test pressure is applied. Unless otherwise permitted, underground piping shall be tested before the joints are covered.

3-3. PRESSURE TESTING. After the piping to be tested has been filled with water or compressed air, the test pressure shall be applied and maintained without interruption for 1 hour plus any additional time required for the Contractor to examine all piping being tested and for the Subcontractor to locate any defective joints and pipe materials.

3-3.01. Test Pressure - Subsurface and Pipeline. Piping from groundwater wells to the treatment plant, within the treatment system, and to the discharge point shall be subjected to a hydrostatic test pressure equivalent to 80 psig.

3-4. LEAKAGE TESTING. Following completion of pressure testing and acceptance by the Contractor, the piping shall be subjected to a leakage test. The duration of the leakage test shall be 2 hours plus the additional time required for the Contractor to make an accurate determination of leakage.

3-4.01. Leakage Test Pressure. The hydrostatic pressure maintained during the leakage test shall be at least 75 percent, but not more than 100 percent, of the pressure specified for pressure testing of the piping and shall be maintained within plus or minus 5 percent during the entire time that leakage measurements are being performed.

3-4.02. Leakage Measurement. Measurement of leakage shall not be attempted until all trapped air has been vented and a constant test pressure has been established. After the pressure has stabilized, piping leakage shall be measured with a suitable water meter installed in the pressure piping on the discharge side of the force pump.

3-4.03. Allowable Leakage. The term "leakage", as used herein, refers to the total amount of water which must be introduced into the piping during the leakage test to maintain the test pressure.

No piping will be accepted if and while it exhibits a leakage rate in excess of that determined by the following formula:

$$Q = 0.0075 \text{ DLN (using inch-pound units)}$$

where

Q = allowable leakage in gallons per hour

D = nominal diameter of pipe in inches

L = length of section tested in thousand feet

N = square root of average test pressure in pounds per square inch

Whenever the piping to be tested contains pipe of different diameters, the allowable leakage shall be calculated separately for each diameter and the corresponding length of piping. The resulting allowable leakage rates shall be added to obtain the total allowable leakage for the entire piping.

All joints in piping shall be watertight and free from visible leaks during the leakage test. Each leak which is discovered within the correction period stipulated in the General

Conditions shall be repaired by and at the expense of the Subcontractor regardless of the amount that the total leakage may have been below the specified allowable leakage rate during the leakage test.

If the leakage test indicates a higher than allowable leakage rate, the Subcontractor shall locate and repair leaking joints and other defective work to the extent necessary to reduce the leakage to an acceptable value.

End of Section

## SECTION 02930 - SEEDING AND SODDING

### PART 1 - GENERAL

1-1. SUMMARY. This section covers the establishment of grass-covered areas for restoring and stabilizing soils cut by the line of trench or damaged by construction, whether within or outside the easement, including seed and sod bed preparation, fertilizing, planting, mulching, and maintenance. The Subcontractor shall provide all materials, labor, and equipment to complete all seeding and sodding work in accordance with the Subcontract Drawings and specifications and to the complete satisfaction of the owner or the agency or authority having jurisdiction over the property, USEPA and the Contractor.

Unless otherwise specified or directed by the Contractor, all established lawn areas shall be sodded. All other areas, unless cultivated or otherwise covered by structures, pavement, aggregate surfacing, or other surface treatment, shall be restored by seeding.

Temporary seeding for erosion control during construction shall be performed by the Subcontractor as directed by the Contractor, USEPA, or State and Local Authorities.

All work of this section shall be performed by experienced personnel who are familiar with performing this type of work. Subcontractor shall provide adequate supervision by a qualified foreman at all times when seeding is in progress, and shall have access to equipment of proper size and capacity to perform the work as specified and within the limits disturbed by construction.

The measurement and payment for the work of this section shall be in accordance with Specification Section 01025 - Measurement and Payment.

1-2. REFERENCES. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

1-2.01. American Society for Testing and Materials (ASTM):

ASTM C 136-84a Sieve Analysis of Fine and Coarse Grain-Aggregates.

ASTM D 1556-82 Density of Soil in Place by the Sand-Cone Method.

ASTM D 1557-78 Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (454-kg) Hammer and 18-in. (457-mm) Drop.

ASTM D 2028	(1976; Rev. 1986) Cutback Asphalt (Rapid-Curing Type).
ASTM D 2487-85	Classification of Soils for Engineering Purposes.
ASTM D 2607	(1969) Peats, Mosses, Humus, and Related Products.
ASTM D 2922-81	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
ASTM D 3017-78	Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

1-2.02. American Sod Producers Association, Inc. (ASPA):

ASPA-01	(Undated) Guideline Specifications to Sodding.
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1-2.03. Federal Specification (FS):

FS O-F-241	(Rev. D) Fertilizers, Mixed, Commercial.
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1-2.04. U.S. Department of Agriculture (USDA):

USDA-01	(1939) Federal Seed Act of August 9, 1939 (53 Stat. 1275) Rules and Regulations
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1-2.05. Delaware Department of Environmental Protection (DEP):

State of Delaware, DNREC, *Erosion and Sediment Control Handbook*.

1-2.06. Delaware Department of Transportation (DelDOT):

DelDOT, Section 732, *Topsoil*.

DelDOT, Section 733, *Topsoiling*.

DelDOT, Section 734, *Seeding*.

DelDOT, Section 735, *Mulching*.

DelDOT, Section 736, *Sodding*.

1-3. SUBMITTALS. Prior to the start of any seeding or sodding activities, Subcontractor shall submit to Contractor the following in accordance with Specification Section 01300 - Submittals.

1-3.01. Manufacturer's Catalog Data. Manufacturer's literature discussing physical characteristics, application, and installation instructions for erosion control material and for chemical treatment material shall be submitted.

1-3.02. Soil Test. Subcontractor shall supply a copy of the soil test used to determine quantity of lime and admixtures.

1-3.03. Certificates of Compliance. Prior to the delivery of materials, certificates of compliance shall be submitted certifying that materials meet the requirements specified. Certified copies of the reports for the following materials shall be submitted.

1-3.03.01. Seeds. For mixture percentage, pure live seed, weed seed content, germination.

1-3.03.02. Fertilizer. For chemical analysis composition percent.

1-3.03.03. Lime. For chemical analysis.

1-3.03.04. Top Soil. For compliance with paragraph 2.1.6: Topsoil.

1-3.04. Material safety data sheets for all material brought onsite.

1-3.05. A copy of suppliers' invoices for all sod, seed, mulch, lime, and fertilizer, showing the quantity purchased for the project.

1-3.06. Delaware Department of Agriculture registration and proper labels for all types of seed, fertilizer, lime, mulch, mulch anchors, and topsoil.

#### 1-4. DELIVERY, STORAGE, AND HANDLING.

##### 1-4.01. Delivery.

1-4.01.01. Inspection. Turf, sod, seed and fertilizer material shall be inspected by the Contractor upon arrival at the jobsite, and unacceptable material shall be removed from the jobsite at Contractor's discretion and at Subcontractor's expense.



1-4.01.02. Protection. Materials shall be protected from deleterious effects of sun, wind, rain, heat, cold, moisture, rodents, or other causes.

1-4.01.03. Fertilizer and Lime: Delivery of fertilizer and lime to the site shall be in original, unopened containers bearing manufacturer's chemical analysis. Instead of containers, fertilizer and lime may be furnished in bulk. A certified chemical analysis shall be provided for bulk deliveries.

1-4.01.04. Soil Amendments. Soil amendments shall be delivered to the site in the original, unopened containers bearing the manufacturer's chemical analysis. In lieu of containers, soil amendments may be furnished in bulk. A certified chemical analysis shall be provided for bulk deliveries.

1-4.01.05. Sod. Delivery of sod shall be so timed that the sod will be transplanted within 36 hours unless a suitable preservation method is employed prior to delivery. Sod not transplanted within this period shall be inspected and approved by the Contractor prior to placement.

1-4.01.06. Seed. Seed shall be furnished in the vendor's sealed standard containers bearing the date of last germination, which shall be within 6 months prior to planting. Seed which has become wet, moldy, or otherwise damaged in transit or storage will not be accepted.

1-4.02. Storage. Materials shall be stored in areas designated by the Contractor. Seed, lime, and fertilizer shall be stored in cool, dry locations away from contaminants. Chemical treatment materials shall not be stored with other landscape materials.

1-4.03. Handling. Except for bulk deliveries, materials shall not be dropped or dumped from vehicles. Open or damaged containers may be rejected at the Contractor's discretion.

## PART 2 - PRODUCTS

### 2-1. MATERIALS.

#### Permanent Seed

Formula meeting the requirements of DelDOT Section 734, at a rate of 2.3 pounds per 1000 square feet. Seed shall be certified, premixed, and seed bags shall have an inspection tag, stamped, dated, and signed by the Delaware Department of Agriculture.

	Seed from containers that are not sealed or that have been stored with herbicides shall not be used.
Fertilizer	10-20-20, dry formulation, meeting the requirements of DelDOT Section 734 added at a rate of 15.6 pounds per 1000 square feet.
Limestone	Pulverized, agricultural grade, meeting the requirements of DelDOT Section 734, added at a rate of 88.9 pounds per 1000 square feet.
Mulch	Hay or straw mulch, meeting the requirements of DelDOT Section 735, added at a rate of 133 lbs per 1000 square feet. Mulch shall be free of weed seeds, foreign material, coarse stems, and any substances toxic to plant growth.
Topsoil	Friable and loamy meeting the requirements of DelDOT Section 732 and meeting the requirements for loam, sandy loam, silt loam, sandy clay loam, or clay loam as defined by the USDA soil classification system. Topsoil shall be free of debris, trash, stumps, rocks, roots, and noxious weeds, and shall be able to support healthy vegetation. It shall contain no substance that is potentially toxic to plant growth.

### PART 3 - EXECUTION

3-1. Sequence. Unless otherwise requested in writing and acceptable to the Contractor, the sequence of work shall be as follows: clearing, grading, application of soil amendments, tilling, seeding or sodding, covering and firming, mulching seeded areas, anchoring mulch, cleanup, protection, and maintenance.

3-1.01. Seeding Time. Seeding and sodding work shall progress as rapidly as portions of the site become available, working within seasonal limitations.

Seeding dates shall be defined from March 15 to October 1 unless written permission is given by the USEPA or Contractor to extend the planting season. Sodding will be permitted whenever the ground is in a workable condition and the temperature is consistently above freezing. Sod shall not be placed between November 15 and March 1 without written approval of the Contractor or USEPA.

Planting shall be done only during the planting season, when weather and soil conditions are suitable. No planting shall be done during severe drought, high winds, excessive moisture, or frozen ground, as determined by the Contractor. Seeding and sodding work in any area shall not be started until all earthwork has been substantially completed. Backfills and fills shall be allowed to settle, topsoil spread and bound, finish grading completed, and all required mechanical compaction completed and accepted before commencing work in any area.

3-1.02. Clearing. Prior to grading and tilling, vegetation that may interfere with operations shall be mowed, grubbed, and raked. The collected material shall be removed from the site. The surface shall be cleared of stumps, stones larger than 2 inches, roots, cable, wire, and other materials that might hinder the work or subsequent maintenance.

3-1.03. Grading. Finished grades shall be 1/2 inch below the grades of adjacent walks, driveways and pavements. Eroded areas and areas having inadequate drainage, as indicated by ponding of water, shall be filled. Ruts, deep tracks, dead furrows, and ridges shall be eliminated.

3-1.04. Application of Soil Amendments.

3-1.04.01. Soil Test. A soil test shall be performed for, but not limited to: pH, chemical analysis, and mechanical analysis to establish the quantities and type of soil amendments required to meet local growing conditions for the type and variety of seed, sod and turf specified.

3-1.04.02. Lime. Lime shall be applied at the rate as recommended by the soil test. Lime shall be incorporated into the soil to a minimum depth of 4 inches or may be incorporated as part of the tillage operation.

3-1.04.03. Fertilizer. Fertilizer shall be applied at the rate as recommended by the soil test. Fertilizer shall be incorporated into the soil to a minimum depth of 4 inches or may be incorporated as part of the tillage or hydroseeding operation.

3-1.04.04. Conditioner. Soil conditioner shall be spread uniformly over the soil to a minimum depth as required by the Soil Test and thoroughly incorporated by tillage into the soil to a minimum depth of 4 inches.

3-1.04.05. Deviations. Deviations in the ground surface in relation to the grades indicated shall be corrected prior to seeding, sodding and turfing.

3-1.05. Tillage. After spreading fertilizer and lime, areas to be seeded and sodded shall be tilled in order to incorporate the lime and fertilizer, break up soils compacted by construction, and promote rooting. The finished operation should result in a well aggregated soil to retain moisture and to protect the seed against temperature fluctuations. Except in compacted, crusted, loose, and smooth areas, the soil shall be tilled to a depth of at least 2 inches. In all other areas, the soil shall be tilled to at least 6 inches. In small, inaccessible areas or on steep embankments, the minimum depth of tilling shall be 2 inches. Tilling may have to be done manually. After tilling, the sod or seedbed shall be smoothed by harrowing or dragging to eliminate clods and voids. All areas shall be brought to the original grade prior to starting construction. If the surface is not acceptable to the Contractor, the Subcontractor shall rework the unacceptable portions. The finished surface shall be even and uniform and no dirt clods, rocks, or other debris larger than 2-1/2 inches in diameter shall remain on the surface. If, in the opinion of the Contractor the soil additives have not been thoroughly mixed, the Subcontractor shall recultivate the site at his own expense.

3-1.06. Application of Seed. Seeding equipment calibration tests shall be made in the presence of the Contractor to determine the equipment setting required to broadcast the seed at the specified rates. Markers shall be used to assure that no skips in planting occur. If unplanted skips or areas are noted after germination and growth of the grass, the unplanted areas shall be seeded at no additional cost to the Owner. The seeder shall be kept at least half-full during the seeding to ensure uniform distribution of the seed mixture over all areas to be seeded and shall be adjusted so that the seeds can be planted and covered deeper than 1/4 inch. On slopes of 3:1 or flatter, seeding shall be done with grass seed drills or seeders.

No seeding or fertilizing shall be done during periods of severe drought, high winds or excessive moisture. No seeding shall be done on frozen ground or when the temperature is 32° F (0° C) or lower.

The Subcontractor may apply the seed by the hydroseeding method using wood cellulose fiber applied at the rate of 40 pounds per 1,000 square feet. However, the fiber mulch shall be applied in two separate operations. Ten percent of the specified rate of fiber mulch shall be applied with the

seed and the remainder applied after seeding. A sheet of plywood or other suitable method shall be used to protect edges, fencing, and structures from overspray.

3-1.07. Covering and Firming. Unless a cultipacker type seeder is used, the seed shall be covered with a shallow-set spike tooth harrow or a chain, plank, or brush drag, depending on soil conditions. The depth of cover shall not exceed 1/4 inch. In small areas or on steep slopes, covering may have to be performed by hand. After covering, the areas shall be firmed by rolling or with a cultipacker.

3-1.08. Application of Mulch. Mulch shall be spread uniformly in a continuous blanket at a rate approximately 1-1/2 inches to 2-1/2 inches, averaging approximately 2 inches in loose condition. Mulch shall be spread by hand or with a blower type mulch spreader. Blower type mulch spreaders shall be adjusted and operated to prevent excessive breakage of the mulch material. If this is not possible, the mulch shall be spread by hand. Care shall be exercised to collect all baling wire as it is removed from the bale. Mulching shall be started at the windward side of relatively flat areas, or at the upper part of a steep slope, and continued uniformly until the area is covered. The mulch shall not be bunched. Mulch on seeded areas shall be placed not later than two workdays after the seeding.

The mulch shall be anchored in the soil to a depth of 2 to 3 inches by a mulch puncher or a straight serrated coulter disk mulch anchor machine designed to force the mulch into the soil. The machine shall be weighted and operated to secure the mulch firmly into the ground and to prevent loss or bunching by wind. The coulters shall be at least 10 inches in diameter. Two or more passes may be required to anchor the mulch to the satisfaction of the Contractor. Only as much mulch shall be placed as can be anchored on the same day.

3-1.09. Wood Cellulose. Wood cellulose fiber shall be applied either as a waterborne mixture, with the fibers uniformly suspended in water and applied to seeded areas, or in a homogeneous mixture of fertilizer, seed, and fiber mulch, uniformly applied to prepared areas at the specified rates. Wood cellulose fiber shall be applied by hydraulic pressure equipment.

Unless otherwise specified, the wood cellulose fiber shall be applied at a rate of at least 2,000 pounds per acre, based on the dry weight of the fiber.

3-1.10. Transplanting Sod. During periods of higher than optimal temperature and after all unevenness in the soil surface has been corrected, the soil shall be lightly moistened immediately prior to laying the sod.

The first row of sod shall be laid in a straight line; subsequent rows shall be placed parallel to and tightly against each other. Lateral joints shall be staggered to promote uniform growth and strength.

Care shall be exercised to avoid stretching or overlapping the sod and to butt all joints tight in order to prevent air drying of the roots. Sod segments smaller than 2 square feet shall not be incorporated in the Work. As sodding is completed in any one section, the sod shall be pressed into the sod bed by tamping or rolling, to eliminate air pockets, produce a true and even surface, and to assure knitting without displacement or deformation of the sod surfaces. Following compaction, all cracks shall be filled with screened soil of good quality. Excess soil shall be worked into the grass with rakes or other suitable equipment. The sod shall then be thoroughly watered to a sufficient depth to thoroughly wet the underside of the new sod pad and the soil immediately below it.

The finished grade of the sod bed shall be 1 inch below the finished grade of the walks, and sod shall be placed to a final grade 1/4 inch below the finished grade of the walks. Staking will not be required unless the sod cannot be transplanted and maintained as specified herein. If required, six stakes shall be used per square yard or roll of sod. Stakes shall be of lath or similar materials and shall be driven 6 inches into the ground, leaving approximately 1/2 inch of the top above the sod line.

3-1.11. Protection. Seeded and sodded areas shall be protected against traffic, if necessary, by erecting barricades and warning signs. Any protective devices shall be maintained until final acceptance of the project. Procedures used to protect the sod within the limits of the property shall be approved by the property owner.

3-1.12. Cleanup. After completion of the construction, the entire area shall be cleared of excess soil and waste material, including, but not limited to, stones, stumps, roots, brush, wire, grade stakes, and all objects that might hinder maintenance or affect the appearance of the site. All haul roads, regardless of the type of surfacing, shall be kept clean, and soil clods and debris shall be removed. The wheels of vehicles shall be cleaned to avoid tracking soil on the roads, walks, and other paved areas.

3-2. MAINTENANCE. All seeded and sodded areas shall be maintained by the Subcontractor until acceptance of the work as specified herein. Maintenance shall include mowing, watering of sod, reseeding or resodding, repair of erosion damage, and maintenance of mulch. During the establishment period, all lawns shall be adequately watered and be kept mowed to a height of 1-1/2 to 2 inches.

Seeded areas will be accepted when there is a uniform stand of grass at least 2 inches tall and reasonably free of weeds.

3-2.01. Watering. Watering will be required for sodded areas only. Sodded areas representing one day's planting shall be watered sufficiently to wet the sod pads and at least 2 inches of the sod bed. Thereafter in the absence of adequate rainfall, watering shall be done daily and as often as necessary to keep the sod pads moist at all times. Watering shall continue until acceptance.

3-2.02. Replanting. Prior to acceptance, sodded and seeded areas that show signs of substantial desiccation, as evidenced by loss of color and distinct yellowing or lack of germination, shall be considered failed and shall be resodded or reseeded. Resodding or reseeding shall be repeated until an acceptable cover is obtained. Replanting shall be done as originally specified.

3-2.03. Maintenance of Grades. Original grades of grass-covered areas shall be maintained after commencement of planting and until acceptance. Any damage to the finished surface caused by construction shall be repaired within a reasonable time. In the event of erosion, either as a result of watering or caused by rainfall, the damage shall be repaired within a reasonable time. Ruts, ridges, tracks, and other surface irregularities shall be corrected, and reseeded or resodded as required.

3-2.04. Maintenance of Mulch. Mulch shall be maintained until it is covered with growing grass seedlings. Material that has been removed from the site by wind or other causes shall be replaced and secured.

3-2.05. Mowing. All sodded areas shall be mowed immediately prior to the Contractor's "inspection for acceptance." Mowing is required to facilitate visual assessment and acceptability of the work. Mowing shall not be attempted until the sod is firmly rooted and secure in place. Not more than 1/3 of the grass leaf shall be removed. Any debris that would interfere with mowing shall be collected and removed.

End of Section

## SECTION 02950 - TREES

### PART 1 - GENERAL

1-1. SCOPE. This section covers the requirements necessary to preserve, remove, replace, and maintain trees as indicated on the Subcontract Drawings or otherwise affected by the Work.

1-2. GENERAL REQUIREMENTS. Subcontractor shall provide all materials, labor, equipment, and services to complete the work of this section and as indicated on the Subcontract Drawings.

All pruning, removal, and replacement of trees shall be performed by qualified nurserymen or horticulturists. Subcontractor shall provide adequate supervision by a qualified foreman at all times during tree work, and shall have access to equipment of proper size and capacity to perform the work as specified and within the limits disturbed by construction.

The measurement and payment for the work of this section shall be in accordance with Specification Section 01025 - Measurement and Payment.

1-3. REFERENCES. Subcontractor shall furnish, install, and maintain all materials for this section in accordance with the Subcontract Documents and all applicable rules and regulations, codes, and ordinances of Local, State, and Federal authorities including, but not limited to:

- A. Delaware Department of Natural Resources and Environmental Control (DNREC), *Erosion and Sediment Control Handbook for Development*.
- B. Site Health and Safety Plan.
- C. Delaware Department of Transportation (DelDOT), Section 737, *Planting*.
- D. DelDOT, Section 741, *Tree Removal*.

1-4. SUBMITTALS. Prior to the start of Work, Subcontractor shall submit to Contractor copies of all necessary tree cutting permits, and material data for fertilizer, mulch, tree wrapping, and stump treatment herbicide.

Prior to planting new trees, Subcontractor shall submit to Contractor Delaware Department of Agriculture inspection tags and identification labels for all new trees, fertilizer, and mulch.

All submittals required by this section shall be in accordance with Specification Section 01300 - Submittals.



## PART 2 - PRODUCTS

2-1. MATERIALS. Subcontractor shall furnish all miscellaneous tools, equipment, and materials required to remove, replant, maintain, and preserve trees in accordance with the Subcontract Documents.

New trees shall be nursery grown, have a normal habit of growth, have well-developed branch and root systems, and have weather resistant identification labels securely attached in a fashion that will not interfere with normal growth.. Trees shall be sound, healthy, vigorous, and free from defects, disfiguration, injury, disease, insect eggs, or infestation of any kind. Trees with weak, thin trunks which are not capable of self-support when planted or have lopsided growth will not be acceptable. Trees must have been grown under similar climatic conditions and in similar soils to those at the project site for two years prior to planting. Trees must be freshly dug and shall not have been heeled-in or in cold storage prior to planting.

All new trees shall have a minimum trunk diameter of 1.5 inches, a minimum height of 6 feet, and be balled and burlaped. Subcontractor, at no additional cost to Contractor, may furnish new trees larger than the minimum specified dimensions. Balls shall be wrapped with burlap, be firm, and shall be securely tied with heavy twine. Balls shall not be cracked, or broken.

Subcontractor shall provide all water required for tree planting and maintenance in accordance with Specification Section 01500 - Temporary Facilities.

Prior to the start of Work, Contractor will determine the types of new trees and notify Subcontractor.

Fertilizer	20-10-5 fertilizer, meeting the requirements of DelDOT Section 737.08.
Mulch	Chopped pine bark, licorice root, shredded hardwood bark, wood chips, tan bark, or an approved equal meeting the requirements of DelDOT Section 737.08. If fresh wood chips or wood shavings are used or if organic material is added to planting bed, then a slow release high nitrogen fertilizer should be used in addition to the completer. Mulch should cover the entire planted slope.
Topsoil	Shall be loam, sandy loam, silt loam, sandy clay loam, or clay loam or loamy sand as approved by an

agronomist or soil scientist and meeting the requirements of DelDOT Section 737.06. Topsoil shall contain no more than 5% by volume of debris, trash, stumps, rocks, roots, and be free of noxious weeds, and shall be able to support healthy vegetation. It shall contain no substance that is potentially toxic to plant growth. A pH of 5.5 to 6.8 and an organic content of not less than 2% nor greater than 10% are required.

Soil Amendments

Peat moss or peat humus meeting the requirements of DelDOT Section 737.07.

Stakes and Guys

All stakes, guys and related materials shall meet the requirements of DelDOT Section 737.10 and be approved by Contractor.

Tree Wrapping

100 to 150 mm wide strips of clean, new burlap of 7 to 8 oz/yd<sup>5</sup> or waterproof paper for tree wrapping, 30-30-30 rating in 100 mm wide strips, meeting the requirements of DelDOT Section 737.10.

### PART 3 - EXECUTION

3-1. Tree Preservation. No trees shall be removed, unless their removal is indicated on the Subcontract Drawings and authorized by Contractor. Subcontractor shall take extra measures to protect trees or other vegetation designated to be preserved, such as erecting barricades, trimming to prevent damage from construction equipment, and installing pipe and other Work by means of hand excavation or tunneling methods. Such trees or other vegetation shall not be endangered by stockpiling excavated material or storing equipment against the trunk.

3-2. Tree Removal. Subcontractor shall remove existing trees where indicated on the Subcontract Drawings and as directed by Contractor. Subcontractor shall safely remove trees in sections and grind stumps to at least 250 mm below the ground surface. All power tools, rigs, or other equipment furnished by Subcontractor to remove trees and grind stumps, shall be used by Subcontractor in accordance with the manufacturers' safety recommendations, including appropriate personal protective equipment. Subcontractor shall perform tree removal and stump grinding in accordance with DelDOT Section 741 and in a manner that prevents damage to any existing structures, other trees, utilities, or other public or private property.

Subcontractor shall treat live stumps of cut trees with herbicide on the day of cutting. Subcontractor shall apply herbicide in accordance with the manufacturer's recommendations. Subcontractor shall

repeat application of herbicide, as directed by Contractor, if sprouts develop prior to completion of the Work.

Subcontractor shall acquire and maintain all necessary tree cutting permits. Subcontractor shall coordinate tree cutting with the affected property owners and utility companies. Subcontractor shall submit to Contractor copies of all tree cutting permits.

All trees which must be removed to perform the Work shall be handled and disposed of by Subcontractor in accordance with Specification Section 01606 - Materials Handling and Disposal.

3-3. Delivery, Storage, and Handling. Subcontractor shall exercise care in the transportation, unloading, storage, and handling of new trees and associated materials. Subcontractor shall handle trees so that roots and branches are protected and balls are kept from drying out. Subcontractor shall not handle trees by the trunk or branches.

3-4. Site Preparation. In preparation for tree planting, Subcontractor shall clear the planting area of excess soil and waste materials including but not limited to stones, stumps, roots, brush, wire, grade stakes, and all objects that might be a hindrance to planting operations. Subcontractor shall handle and dispose of materials generated as a result of site preparation, in accordance with Specification Section 01606 - Materials Handling and Disposal.

3-5. Planting Locations. Subcontractor shall plant new trees where indicated on the Subcontract Drawings and as directed by Contractor. Should obstructions prevent planting at the specified locations, Contractor will determine alternate locations for new trees.

3-6. Excavation of Plant Pits. Upon Contractor's approval of planting locations, Subcontractor shall excavate pits for planting new trees. Subcontractor shall perform the excavation of planting pits to the dimensions indicated on the Subcontract Drawings and in accordance with Specification Section 02200 - Earthwork. Planting pits shall have vertical sides, flat bottoms, and shall be large enough to accommodate the ball without crowding. The crown of the tree must be at the same level in relation to finished grade as it did in its place of growth.

3-7. Planting. Prior to planting new trees, Subcontractor shall scarify, loosen, or roughen the inside surfaces of the planting pits. Subcontractor shall center trees within the planting pit and set plumb for backfilling. Trees with damaged roots or balls shall not be used and shall be replaced by Subcontractor at no additional cost to Contractor. A ring of earth shall be formed around the plant to produce a dish for watering and must be watered immediately after planting. Planting shall adhere to DelDOT Section 737.12 and Sections 737.14 through 737.17.

3-8. Backfilling. Subcontractor shall backfill planting pits with a uniform mixture of topsoil meeting the requirements of DelDOT Section 737.13. Subcontractor shall place and hand compact

the backfill mixture in layers around the ball in a manner to avoid injury to the ball or disturbing the position of the tree.

When backfilling is two-thirds completed, Subcontractor shall cut away or fold back the top one-third of the burlap wrapping and thoroughly water the ball. After the water has been absorbed, Subcontractor shall complete backfilling to grade and thoroughly water the planting area again. Any subsequent settlement shall be brought to grade by Subcontractor using additional backfill.

3-9. Fertilizing. Subcontractor shall place 20-10-5 fertilizer, meeting requirements of DelDOT Section 737.08 and in tablet form weighing a minimum of 20 g per tablet, evenly around perimeter of root ball, no higher than halfway up the root ball. One tablet is required for each 13 mm of tree trunk diameter or as otherwise specified in DelDOT 737.14.

3-10. Wrapping, Staking, and Guying. Upon backfilling and fertilizing, Subcontractor shall wrap the trunks of all new deciduous trees from the ground to the lowest main branches. Subcontractor shall wrap tree trunks spirally, with an approximate 38 mm overlap of the wrappings. Subcontractor shall securely tie the wrapping with twine or equivalent at the top, bottom, and at 300 mm intervals along the trunk.

Following wrapping, Subcontractor shall stake or guy new trees as indicated on the Subcontract Drawings. Subcontractor shall protect that portion of staking or guying wire that is wrapped around the tree using sections of garden hose, as indicated on the Subcontract Drawings. Trees shall stand plumb after staking and guying has been completed.

3-11. Mulching. Upon completion of staking or guying, Subcontractor shall place a 100 mm layer of mulch to the limits indicated on the Subcontract Drawings.

3-12. Pruning. Upon mulching, Subcontractor shall prune each tree in accordance with accepted horticultural practices to preserve the natural character of the tree and in a manner fitting its use in the landscape design. Subcontractor shall perform all pruning with sharp tools to perform clean, flush cuts by workers skilled in this operation. Subcontractor shall prune all injured or dead wood. Subcontractor shall not cut main leaders. The natural habit or shape of the tree shall not be altered. Any cuts over 19 mm in diameter and bruises or scars on the bark will also remove the injured cambium back to living tissue. Wounds must be smoothed and shaped so the branch bark ridge is preserved.

3-13. Cleanup. Upon completion of tree planting activities, Subcontractor shall clear the tree planting areas of excess soils, waste materials, and all other undesirable objects. Subcontractor shall clean all roads, driveways, or other private and public property of dirt and soil clods left as a result of tree removal and replacement, to the satisfaction of Contractor. Subcontractor shall handle and dispose of all cleanup materials in accordance with Specification Section 01606 - Materials Handling and Disposal.

3-14. Maintenance. Subcontractor shall maintain all new trees until one full growing season of one year is passed and completion of the Work is accepted by Contractor. Thereafter, it shall be the property owner's responsibility to maintain new trees. Maintenance shall include but not be limited to frequent watering; resetting trees, stakes and guys; pruning; weeding, and all other operations which, in the opinion of Contractor, are necessary to maintain new trees. Subcontractor shall perform watering in a manner that does not cause erosion or excessive runoff. The schedule for plant establishment must follow DelDOT Section 737.17.

Subcontractor shall repair or replace any new tree that is defective, damaged, or dies prior to completion of the Work and within ten days of discovery. When, in the judgment of Contractor, such defects or damages are the result of poor workmanship or failure to meet the requirements of the Subcontract Documents, then the cost of necessary repairs or replacements shall be borne by Subcontractor.

Once Subcontractor has completed the tree planting in accordance with the provisions of the Subcontract Documents and to the satisfaction of Contractor, no additional tree planting work will be required at Subcontractor's expense.

End of Section

## SECTION 03301 - CAST-IN-PLACE CONCRETE

### PART 1 - GENERAL

1-1. SCOPE. This section covers all cast-in-place concrete, forms, finishing, curing, repair, and other appurtenant work.

1-2. GENERAL REQUIREMENTS. Subcontractor shall furnish, form, place, finish, and repair all cast-in-place concrete as indicated on the Subcontract Drawings and specified herein. Subcontractor shall inform Contractor at least 24 hours in advance of the times and places at which Subcontractor intends to place concrete.

The measurement and payment for the work of this section shall be in accordance with Specification Section 01025 - Measurement and Payment.

### 1-3. REFERENCES.

- A. American Society for Testing and Materials (ASTM), Standard C33, *Standard Specification for Concrete Aggregates*.
- B. ASTM, Standard C94, *Standard Specification for Ready-Mixed Concrete*.
- C. ASTM, Standard C150, *Standard Specification for Portland Cement*.
- D. ASTM, Standard C260, *Standard Specification for Air-Entraining Admixtures for Concrete*.
- E. ASTM, Standard C309, *Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete*.
- F. ASTM, Standard C494, *Standard Specification for Chemical Admixtures for Concrete*.

1-4. SUBMITTALS. Prior to the start of Work, Subcontractor shall submit to Contractor reports and data covering the source and quality of concrete materials, the proposed concrete proportions, and a certification that the proposed concrete proportions will satisfy the mixture requirements of this section.

At the time of delivery, Subcontractor shall submit to Contractor a copy of the delivery ticket for each load of concrete.

All submittals required by this section shall be in accordance with Specification Section 01300 - Submittals.

## PART 2 - PRODUCTS

2-1. LIMITING REQUIREMENTS. Unless otherwise specified, concrete shall be controlled within the following limiting requirements.

2-1.01. Cement Content. The quantity of portland cement in the concrete shall be not less than that indicated in the following table:

Quantity of Cement (lb/yd <sup>3</sup> )				
Concrete Slump	Coarse Aggregate Size from No. 4 Sieve to			
	3/8"	1/2"	3/4"	1"
2 inches	601	573	545	517
3 inches	629	592	564	536
4 inches	639	611	583	555
5 inches	658	630	602	573
6 inches	677	649	620	592

2-1.02. Ratio of Fine to Total Aggregates. The ratio of fine to total aggregates based on solid volumes (not weights) shall be:

Coarse Aggregate Size	Minimum Ratio	Maximum Ratio
3/8 inch	0.45	0.60
1/2 inch	0.40	0.55
3/4 inch	0.35	0.50
1 inch	0.30	0.46

2-1.03. Maximum Water-Cement Ratio. The maximum water-cement ratio shall be 0.42 on a weight basis, or, if fly ash is used, the combined mass of cement plus fly ash shall be used to determine the water-cementitious materials ratio.

2-1.04. Fly Ash Content. At the option of the Subcontractor, fly ash may be substituted for up to 15 percent of the Portland cement, on the basis of 1.5 pounds of fly ash added for each pound of cement reduction.

2-1.05. Coarse Aggregate. The maximum nominal coarse aggregate size shall be 1 inch.

2-1.06. Slump. Concrete slump shall be kept as low as possible consistent with proper handling and thorough compaction. Unless otherwise authorized by the Contractor, slump shall not exceed 4 inches.

2-1.07. Total Air Content. The total volumetric air content of concrete after placement shall conform to the following table.

Nominal Maximum Aggregate Size (inches)	Air Content (Percent) " 1 %
3/8	6
1/2	5 1/2
3/4	5
1	4 1/2

2-1.08. Admixtures. The admixture content, batching method, and time of introduction to the mix shall be in accordance with the manufacturer's recommendations. A water-reducing admixture and an air-entraining admixture shall be included in all concrete. No calcium chloride or admixture containing chloride from sources other than impurities in admixture ingredients will be acceptable. Admixtures classified as Class 1 or Class 2 in ACI 212R or containing any lignosulfonic acids ("lignins") or their salts will not be acceptable.



2-1.09. Strength. The minimum acceptable compressive strengths, as determined by ASTM C39, shall be:

Age	Minimum Compressive Strength
7 days	3,000 psi
28 days	4,000 psi

2-1.10. Concrete for Manholes, Pipe Blocking, and Pipe Encasement. Concrete for manholes, buried blocking, and encasement of pipe shall conform to the limiting requirements specified herein, except that the cement factor and total water content may be adjusted to provide a minimum compressive strength of 3,000 psi at 28 days. Concrete shall have a slump of not less than 2 inches nor more than 4 inches when placed.

## 2-2. MATERIALS.

Cement	ASTM C150, Type I or II low alkali.
Fly Ash	ASTM C618, Class F, except loss on ignition shall not exceed 4 percent.
Fine Aggregate	Clean natural sand, ASTM C33. Artificial or manufactured sand will not be acceptable.
Coarse Aggregate	Crushed rock, washed gravel, or other inert granular material conforming to ASTM C33, except that clay and shale particles shall not exceed 1 percent.
Water	Clean and free from deleterious substances.
Admixtures	
Water-Reducing	ASTM C494, Type A or D.
Air-Entraining	ASTM C260.
Superplasticizing	ASTM C494, Type F or G.

## Reinforcing Steel

Bars	ASTM A615, Grade 60, deformed.
Welded Wire Fabric	ASTM A185 or A497.
Bar Supports	CRSI Class 1, plastic protected; or Class 2, stainless steel protected.
Mechanical Connections	Erico "Cadweld T-Series" or "Lenton", or Richmond "Dowel Bar Splice System".

## Forms

Plywood	Product Standard PS1, waterproof, resin-bonded, exterior type, Douglas fir.
Lumber	Straight, uniform width and thickness, and free from knots, offsets, holes, dents, and other surface defects.
Form Coating	Nonstaining and nontoxic after 30 days; Burke "Spectrum Release Agent", L&M Chemical "Debond", Master Builders "Pro-Cote", Nox-Crete "Chembetron 103", or Symons "Thrift Kote".
Pre-Cure Finishing Aid	Burke "Finishing Aid Concentrate", Euclid "Eucbar", L&M Chemical "E-Con", Master Builders "Confilm", or Sika "Sikafilm".
Polyethylene Film	Product Standard PS17, 6 mils or thicker.
Membrane Curing Compound and Floor Sealer	Fed Spec TT-C-800, Type I, Class 1, minimum 18 percent solids, nonyellowing, unit moisture loss 0.390 kg/m <sup>2</sup> maximum; Grace "Sealco 800", L&M Chemical "Dress & Seal", Master Builders "Cure-N-Seal 30", ProSoCo "Kure and Seal", Sonneborn

"Kure-N-Seal 0800", or Symons "Cure & Seal 18%".

2-3. PRELIMINARY REVIEW. The source and quality of concrete materials and the concrete proportions/mix proposed for the work shall be submitted to the Contractor for review and approval at least 10 days before the concrete delivered to the Site.

2-4. FORMS. Forms shall be designed to produce hardened concrete having the shape, lines, and dimensions indicated on the drawings. Forms shall be substantial and sufficiently tight to prevent leakage of mortar and shall be maintained in proper position and accurate alignment.

Forms for pavement, curbs, or gutters shall be made of steel and shall be supported on thoroughly compacted earth. The top face of pavement forms shall not vary from a true plane more than 1/4 inch in 10 feet.

Forms shall be thoroughly cleaned and oiled before concrete is placed.

Where concrete is placed against gravel or crushed rock which does not contain at least 25 percent material passing a No. 4 sieve, such surfaces shall be covered with polyethylene film to protect the concrete from loss of water. Joints in the film shall be lapped at least 4 inches.

2-4.01. Form Ties. Form ties shall be of the removable end, permanently embedded body type, and shall have sufficient strength and rigidity to support and maintain the form in proper position and alignment without the use of auxiliary spreaders.

2-4.02. Edges and Corners. Chamfer strips shall be placed in forms to bevel all salient edges and corners, except the top edges of walls and slabs which are to be tooled and edges which are to be buried. Unless otherwise noted, bevels shall be 3/4 inch wide.

2-4.03. Form Removal. Forms shall not be removed or disturbed until the concrete has attained sufficient strength to safely support all dead, live, and construction loads. Care shall be taken in form removal to avoid surface gouging, corner or edge breakage, and other damage to the concrete.

2-5. REINFORCEMENT. Reinforcement shall be accurately formed and positioned and shall be maintained in proper position while the concrete is being placed and compacted. Unless otherwise

indicated on the drawings, the details of fabrication shall conform to ACI 315 and 318. In case of conflict, ACI 318 shall govern. Reinforcement shall be free from dirt, loose rust, scale, and contaminants. Mechanical connections shall be used only as indicated on the drawings.

2-6. BATCHING AND MIXING. Concrete shall conform to ASTM C94 and shall be furnished by an acceptable ready-mixed concrete supplier.

2-6.01. Consistency. The consistency of concrete shall be suitable for the placement conditions. Aggregates shall float uniformly throughout the mass, and the concrete shall flow sluggishly when vibrated or spaded. The slump shall be kept uniform.

2-6.02. Delivery Tickets. A delivery ticket shall be prepared for each load of ready-mixed concrete and a copy of the ticket shall be handed to the Contractor by the truck operator at the time of delivery. Tickets shall indicate the name and location of the concrete supplier, the project name, the mix identification, the quantity of concrete delivered, the quantity of each material in the batch, the outdoor temperature in the shade, the time at which the cement was added, and the numerical sequence of the delivery.

### PART 3 - EXECUTION

3-1. PLACEMENT. The Subcontractor shall inform the Contractor at least 24 hours in advance of the times and places at which he intends to place concrete. The Contractor will perform an inspection of the surface/area where the concrete is to be placed for puddled water, wet spots and muddy spots. No concrete shall be placed without the approval of the Contractor. In the event that concrete work is to be performed during freezing temperatures (or at a time when the potential exists for concrete to be exposed to freezing temperatures within the first 48 hours after placement) protective measures shall be taken to prevent exposure of the concrete to freezing temperatures. These measures shall include erection of a temporary structure with heaters or delay of the concrete work (only if such a delay will not impact the overall project schedule by more than five days).

Concrete shall be deposited continuously as near as possible to its final position. Methods of conveying concrete to the point of final deposit and of placing shall prevent segregation or loss of ingredients. During and immediately after placement, concrete shall be thoroughly compacted and worked around all reinforcement and embedments and into the corners of the forms. Concrete shall

be compacted by immersion-type vibrators, vibrating screeds, or other suitable mechanical compaction equipment. The use of "jitterbug" tampers to compact concrete flatwork will not be permitted.

3-2. FINISHING. Recesses from form ties shall be filled flush with mortar. Fins and other surface projections shall be removed from all formed surfaces, except exterior surfaces that will be in contact with earth backfill.

Unless otherwise specified, unformed surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance, with no unnecessary working of the surface.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a finish of uniform texture and color and the completed finish for unformed surfaces.

3-2.01. Application of Pre-Cure Finishing Aid. Concrete flatwork subject to rapid evaporation due to hot weather, drying winds, and sunlight shall be protected with a pre-cure finishing aid. The finishing aid shall form a monomolecular film on the surface of fresh, plastic concrete to retard evaporation.

Immediately following screeding, pre-cure finishing aid shall be sprayed over the entire surface of fresh, plastic concrete flatwork at a rate of not less than 200 square feet per gallon, in accordance with the manufacturer's recommendations. The spray equipment shall have sufficient capacity to continuously spray finishing aid at approximately 40 psi with a suitable nozzle as recommended by the manufacturer.

The sprayable solution shall be prepared as recommended by the manufacturer.

Under severe drying conditions, additional applications of finishing aid may be required following each floating or troweling, except the last finishing operation.

3-2.02. Pavement and Floor Slabs. Following placement and consolidation, and the disappearance of bleed water, the concrete surface shall be broom finished with a broom acceptable to the

Contractor. The broom shall be not less than 18 inches wide and made from good quality bass or bassine fibers not more than 5 inches long. The broom finishing shall produce regular corrugations not over 1/8 inch deep for pavement and not over 1/16 for floor slabs. The broom shall be pulled square across the surface, from edge to edge, with adjacent strokes slightly overlapped, and shall not tear the concrete surface.

3-2.03. Curb and Gutter. Curb and gutter shall be finished to the shape indicated on the drawings. After the forms have been removed, all exposed edges shall be rounded, using an edging tool with a 1/8 inch corner radius. Exposed surfaces shall be float finished and given a light broom finish applied at right angles to the curb at the time of initial set, using a horsehair broom.

3-2.04. Sidewalks. Concrete surfaces shall be screeded to the proper elevation and contour. All aggregates shall be completely embedded in mortar. Screeded surfaces shall be given an initial float finish as soon as the concrete has stiffened sufficiently for proper working. Any piece of coarse aggregate which is disturbed by the float or which causes a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance, with no unnecessary working of the surface. Initial floating shall be followed by a second floating at the time of initial set.

Floated surfaces shall be given a light broom finish, using a horsehair broom, to provide a nonslip surface. Brooming shall be done at right angles to the length of the walk.

Sidewalks shall be edged using a 3 or 4 inch wide edging tool with a 1/8 inch corner radius. Edger lap marks at corners of each slab shall be carefully removed. False joints shall be provided at right angles to the length of the walk, using a grooving tool with 1/8 inch radius. The finished edge on each side of the joint shall be the same width as the edging tool used. False joints shall divide each sidewalk into square sections.

The finished surface of all sidewalks shall be neat in appearance, shall be sloped to drain, and shall not pond water.

3-3. CURING. Concrete shall be protected from loss of moisture by water saturation or by membrane curing for at least 7 days after placement; however, when concrete is also being protected from low temperatures, the period of curing by saturation shall be 1 day less than the duration of the low temperature protection.

Water saturation of concrete surfaces shall begin as soon as possible after initial set. Unformed surfaces shall be covered with polyethylene film, tarpaulins, or sand to retain the water. Water shall be applied as often as necessary to keep the concrete saturated for the entire curing period. Acceptable methods of water curing are described in ACI 308.

Membrane curing compound may be used instead of water curing on concrete which will not be covered later with mortar or additional concrete. Membrane curing compound shall be sprayed at a coverage rate of not more than 300 square feet per gallon. Unformed surfaces shall be covered with curing compound within 30 minutes after final finishing. If forms are removed before the end of the specified curing period, curing compound shall be immediately applied to the formed surfaces. Curing compound shall be suitably protected against abrasion during the curing period.

Concrete shall be protected against freezing for at least 8 days after placement.

3-4. REPAIRING DEFECTIVE CONCRETE. Defects in concrete surfaces shall be repaired to the satisfaction of the Contractor. All concrete which is honeycombed or otherwise defective shall be cut out and removed to sound concrete, with edges cut square to avoid feathering.

Concrete repair work shall conform to Article 5.3.7 of ACI 301 and shall be performed in a manner that will not interfere with thorough curing of surrounding concrete. Repair work shall be adequately cured.

### 3-5. FIELD CONTROL TESTING.

3-5.01. Air Content. An air content test shall be made on concrete from each batch of concrete from which concrete compression test cylinders are made. The Subcontractor shall provide all equipment and supplies necessary for the testing. Air content shall be determined in accordance with ASTM C231.

3-5.02. Slump. A slump test shall be made on concrete from each batch of concrete from which concrete compression test cylinders are made. Slump shall be determined in accordance with ASTM C143.

3-5.03. Test Cylinders. Compression test specimens shall be made, cured, stored, and delivered to the laboratory in accordance with ASTM C31 and C39.

One set of concrete test cylinders shall be cast for each concrete pour. A set of test cylinders shall consist of four cylinders, two to be broken and to have compressive strengths averaged at 7 days, and two to be broken and to have compressive strengths averaged at 28 days. All concrete required for testing shall be furnished by, and at the expense of, the Subcontractor.

The cured cylinders shall be tested by an independent testing laboratory at the expense of the Subcontractor.

End of Section



## Section 03411 - PRECAST CONCRETE

### PART 1 - GENERAL

1-1. SCOPE. This section covers the design, fabrication, and erection/installation of precast reinforced concrete structures complete with all embedments, accessories, and special construction as specified and indicated on the drawings.

1-2. GENERAL REQUIREMENTS. Precast concrete units shall be furnished and installed complete with all embedments, accessories, and special construction as specified and indicated on the Subcontract drawings.

1-3. QUALITY CONTROL. The precast concrete manufacturing plant shall be approved and/or certified by the Delaware Department of Transportation (DelDOT). The manufacturer shall have produced a product similar to what is being specified for at least two years previous.

The precast erector shall have been regularly engaged for at least five years in the erection of precast structural concrete similar to what is being specified.

Welders shall be qualified in accordance with AWS D1.5.

The Contractor reserves the right to place a duly authorized inspector in the plant at any time work related to the production of units for the Contractor is being performed. The Subcontractor shall notify the Contractor at least 7 days in advance when such work is scheduled to begin.

No unit shall be transported from the plant/manufacturer to the Site prior to approval of that unit by the plant/manufacturer's inspector. Such approval shall be stamped on the precast unit by the plant inspector.

1-4. DRAWINGS AND DATA. Complete drawings and data covering fabrication, layout, and installation shall be submitted in accordance with Specification Section 01300 - Submittals.

Information to be submitted for review shall include:

- Letter or certification from the Subcontractor certifying that the product has been designed and constructed in accordance with the Subcontract Documents.
- Plans and/or elevations locating and defining all material furnished by manufacturer (includes openings, finishes, type of insulation).
- Details of steel reinforcement size and placement.
- Sections and details showing connections, cast-in items and their relation to the structure.
- Description of all loose, cast-in and field hardware.
- Field installed anchor location drawings.
- All dead, live and other applicable loads used in the design.
- Details of sections where concentrated loads are to be applied and where boxouts are provided, including saddles, headers, and other special supports.
- Reports covering source and quality of concrete materials.
- Test reports showing compressive strength of each design mix.
- Test reports for required testing during production.
- If requested by the Contractor, information on plant capability, productivity, certification, quality assurance program, and manufacturing equipment and procedures.

1-5. DELIVERY, STORAGE, AND HANDLING. Prestressed concrete units shall not be damaged during handling and shall be kept from contact with adjacent concrete units. Units shall be stored on timber skids and leveled to avoid twisting or other undesirable stresses. Units shall not be moved from the Manufacturer's yard until completion of the specified curing period. Manufacturer will be responsible for the condition of prestressed units until they are removed from delivery vehicle at the site.

1-6. BASIS OF DESIGN. Except as otherwise required herein, design, fabrication, and installation shall comply with all applicable provisions of the following:

- ACI 318, American Concrete Institute, "Building Code Requirements for Reinforced Concrete".

- Section 602 of DelDOT Standard Specifications – Concrete Structures.

Units shall be designed to support loads as indicated on the drawings.

1-6.01. Design Limitations. The following limitations shall apply to the prestressed concrete:

- The maximum size of aggregate shall be 3/4 inch.
- Units shall have embedments and additional reinforcing to satisfy support and anchorage details.

## PART 2 - PRODUCTS

2-1. MATERIALS. Materials for the precast units shall be new and free from defects, and shall meet the following requirements unless indicated otherwise on the design drawings. All materials shall be suitable for prestressed and precast concrete construction and approved and/or certified by the DelDOT.

Reinforcing Steel	ASTM A615, Grade 60, deformed.
Welded Wire Fabric	ASTM A185.
Deformed Bar Anchors (DBA)	ASTM A496 with a minimum 70,000 yield strength and minimum 80,000 psi tensile strength. TRW/Nelson division or equal.
Headed Studs	ASTM A108 with a minimum 50,000 yield strength and minimum 60,000 psi tensile strength. TRW/Nelson division or equal.
Steel Embedments and Accessories	
Shapes and Plates	ASTM A36, finish per manufacturer's standard.
Bolts and Nuts	

High Strength	ASTM A325, Type 1; tested in accordance with Article 9.2 thereof.
Unfinished	ASTM A307.
Nuts, Self-Locking	Prevailing torque type; IFI-100, Grade A.
Washers	A57M F844.
Insulation	Expanded polystyrene beadboard, 2-1/2 inch thickness minimum.
Concrete	Minimum compressive strength of 5,000 psi at 28 days.
Cement	ASTM C150, Type I or Type III.
Aggregates	As required.
Admixtures	As required.
Water	Clean and free from deleterious substances.
Bearing Pads	As required.
Expansion Joint Filler	ASTM D1752, Type I, preformed sponge rubber as required.

## 2-2. MANUFACTURE.

2-2.01. Manufacture. Manufacturing procedures shall be in compliance with DelDOT requirements.

2-2.02. Embedded Accessories. All plates, inserts, and other accessories which are required to be embedded in the units shall be installed at the time of manufacture. All embedded items shall be accurately positioned and shall be rigidly held in position during concrete placement. It is essential that bearing plates be installed in exact and true position.

Precast units shall be provided with lifting loops or similar devices to facilitate handling as required.

2-2.03. Openings and Inserts. Openings as indicated on the drawings shall be incorporated into the design and fabrication. The drawings shall be carefully reviewed for the openings and inserts required by the work of all trades, and all openings and inserts which are beyond the limitations of field modification shall be provided by the manufacturer. Side edges of openings shall be formed or cut neatly and shall have vertical surfaces. Saddles, headers, lintels, or other suitable supports shall be provided by the manufacturer as necessary for the size and location of openings.

The manufacturer's submittals shall state the limitations for field cutting or modification.

2-2.04. Surface Finish. The exterior surface shall be finished as indicated on the drawings. The interior surface shall be a smooth formed finish.

Formed surfaces shall have a smooth uniform texture and color. All fins and other projections shall be removed from formed surfaces, and all holes and other surface defects shall be repaired to the satisfaction of the Contractor. Where exposed to view after installation, power grinding of repaired areas, and of areas from which fins and projections have been removed, will be required if necessary to obtain a uniform finish.

2-3. CURING. The concrete temperature at the time of placing in the forms shall not be less than 50°F and no more than 90°F unless otherwise directed by the Contractor. Concrete shall be cured by continuous surface saturation or inundation, exposure to steam or saturated air in a tightly closed room or chamber, or other method acceptable to the Contractor. Moist curing shall be maintained for at least 7 days when Type I cement is used, or 48 hours when Type III cement is used. The steam curing period shall be as required to reach minimum compressive strength. Units shall be air cured in the fabricator's yard until they attain an age of at least 30 days.

2-4. TOLERANCES. Tolerances for the precast concrete units shall be as recommended herein and/or on the Subcontract Drawings.

Precast units will be rejected for any of the following:

- Length variation in excess of 1/2 inch (1/4 inch each end) of adjacent units or 1 inch maximum between the longest and shortest units.
- Edges varying as required.

- Deviation from design camber, differential camber between adjacent units of the same design, or warp or camber which cannot be controlled by the fastening system between units.
- Improperly placed accessories or boxouts.
- Unsatisfactory surface finish.
- Exposure of wire mesh, reinforcing steel, or prestressing strand, except where cut off at the ends.
- Honeycomb.
- Fractures, cracks, chips, or spalls which cannot be repaired to the satisfaction of the Contractor.
- Irregularities resulting from damaged forms.

### PART 3 - EXECUTION

3-1. INSTALLATION. The installation of precast concrete units shall be performed by a qualified erector. Precast concrete units shall be set in position to the proper grade and lines in accordance with the Contractor's layout and the Contract drawings. Units shall rest solidly upon the supports, grade, or subgrade without rocking. The subgrade surface of which the units are to be placed shall be prepared per Section 02200 - Earthwork.

Units shall be lifted by means of suitable lifting devices at points provided by the manufacturer. Temporary shoring and bracing, including temporary steel columns, baseplates, and bracing, shall comply with the manufacturer's recommendations. Units shall be properly aligned and leveled as required by the approved submittal drawings. The exposed aggregate finish will be pressure washed after installation.

3-1.01. Welding. If welded connections are required, welding shall be done by qualified welders possessing valid certificates under the qualification procedures of AWS D1.5. Care shall be exercised to avoid overheating and cracking the concrete adjacent to the anchorage plates. All units damaged during welding shall be removed and replaced by the Installer with new, undamaged units at no additional cost to the Contractor.

3-1.02. Field Cutting. All cutting of concrete sections shall be done with suitable concrete saws or core drilling equipment in a manner that will provide smooth, even cut surfaces. Side edges of openings shall have vertical surfaces.

All lifting loops shall be cut off flush with the top surface of the units before any covering materials are placed.

3-1.03. Joints. The joints of all units shall present a neat and uniform appearance.

End of Section

## Section 03600 - GROUT

### PART 1 - GENERAL

1-1. SCOPE. This section covers grouting of pump, motor, and equipment baseplates or bedplates; column baseplates and miscellaneous baseplates; and other uses of grout as indicated on the Subcontract Drawings. Unless otherwise specified, all grouting shall be done with nonshrinking grout.

This section also covers epoxy grouting of anchor bolts, threaded rod anchors, and reinforcing bars to be installed in hardened concrete. Anchor bolts, adhesive anchors, and threaded rod anchors are covered in the anchor bolts and expansion anchors section.

### PART 2 - PRODUCTS

#### 2-1. MATERIALS.

Nonshrinking Grout

Five Star Products "Cementitious or Epoxy Grouts," Grace "Supreme," L&M "Crystex," Master Builders "Masterflow 713 Grout."

Epoxy Grout for Reinforcing  
Bars and Threaded Rod Anchors

Adhesive Moisture-insensitive.

For Floors and Horizontal  
Surfaces

Low Viscosity

Master Builders "Brutem AB (Parts A & B)" or Sika "Sikadur 35, Hi-Mod LV."

Medium Viscosity

Master Builders "Concresive Liquid LPL" or Sika "Sikadur 32, Hi-Mod."

For Vertical Surfaces  
and Overhead Applications

Nonsag consistency; Five Star Products "RS Anchor Gel" or Sika "Sikadur 31, Hi-Mod Gel".

Epoxy Grout for Headed



## Anchor Bolts

Adhesive Moisture-insensitive; Five Star Products "RS Anchor Gel".

## Aggregate

As recommended by the epoxy grout manufacturer.

## Water

Clean and free from deleterious substances.

## Reinforcing Bars

ASTM A615, Grade 60, deformed.

## PART 3 - EXECUTION

### 3-1. NONSHRINKING GROUT.

Nonshrinking grout shall be furnished factory premixed so that only water is added at the jobsite. Grout shall be mixed in a mechanical mixer. No more water shall be used than what is specified by the manufacture.

3-1.01. Preparation. The concrete foundation to receive nonshrinking grout shall be saturated with water for at least 12 hours preceding grouting unless additional time is required by the grout manufacturer.

3-1.02. Placement. Unless otherwise specified or indicated on the drawings, grout under baseplates shall be 1-1/2 inches thick. Grout shall be placed in strict accordance with the directions of the manufacturer so that all spaces and cavities below the top of baseplates and bedplates are completely filled, without voids. Forms shall be provided where structural components of baseplates or bedplates will not confine the grout.

3-1.03. Edge Finishing. In all locations where the edge of the grout will be exposed to view, the grout shall be finished smooth after it has reached its initial set. Except where shown to be finished on a slope, the edges of grout shall be cut off flush at the baseplate, bedplate, member, or piece of equipment.

3-1.04. Curing. Nonshrinking grout shall be protected against rapid loss of moisture by covering with wet cloths or polyethylene sheets. After edge finishing is completed, the grout

shall be wet cured for at least 3 days and then an acceptable membrane curing compound shall be applied.

3-2. EPOXY GROUT. Epoxy grout shall consist of a two-component liquid epoxy adhesive of viscosity appropriate to the location and application, and an inert aggregate filler component, if recommended by the adhesive manufacturer. Components shall be packaged separately at the factory and shall be mixed immediately before use. Proportioning and mixing of the components shall be done in accordance with the manufacturer's recommendations.

3-2.01. Preparation. Anchor bolts, threaded rod anchors, and reinforcing bars shall be epoxy grouted in holes drilled into hardened concrete. Diameters of holes shall be as follows:

<u>Item</u>	<u>Diameter of Hole</u>
Reinforcing Bars and Threaded Rod Anchors	1/8 inch larger than the outside diameter of the bar or the rod
Headed Anchor Bolts	Bolt diameter plus 2 inches

The embedment depth for epoxy grouted anchor bolts, threaded rod anchors, and reinforcing bars shall be at least 15 bolt, rod, or bar diameters, unless otherwise indicated on the drawings.

Holes shall be prepared for grouting as recommended by the grout manufacturer.

3-2.02. Installation. Anchor bolts, threaded rod anchors, and reinforcing bars shall be clean, dry, and free of grease and other foreign matter when installed. The bolts, rods, and bars shall be set and positioned and the epoxy grout shall be placed and finished in accordance with the recommendation of the grout manufacturer. Care shall be taken to ensure that all spaces and cavities are filled with epoxy grout, without voids.

During assembly of all threaded stainless steel components, anti-seize thread lubricant shall be liberally applied to the threaded portion not embedded in concrete.

3-3. TESTING. Three (3) Cube samples for compression tests shall be collected by the Subcontractor and tested at an independent laboratory per ASTM C 109 for each day of

grouting. Samples shall be tested at 7 days and results compared to the manufacturers specifications for acceptance.

End of Section

## Section 11180 - SUMP PUMPS

### PART 1 - GENERAL

1-1. SCOPE. This section covers single-stage, enclosed shaft, vertical centrifugal duplex sump pumps.

Each pump shall be complete with an electric motor, controls, support pipe, discharge pipe, shafting, bearings, motor support pedestal, baseplate, anchor bolts, and all other appurtenances specified or required for proper operation.

1-2. GENERAL. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with detail drawings, specifications, contractor data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by the Contractor. Definition of terms and other hydraulic considerations shall be as set forth in the Hydraulic Institute Standards.

1-2.01. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section.

1-2.02. Power Supply. Power supply to each pump motor will be 230 volts, 60 Hz, 3 phase.

1-3. SUBMITTALS. Complete fabrication, assembly, foundation, and installation drawings, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the submittals section. The data and specifications for each unit shall include, but shall not be limited to, the following:

#### Pumps

Name of manufacturer.

Type and model.

Rotative speed.

Size of discharge pipe.

Net weight of pump and motor.

Complete performance curves showing capacity versus head.

Data on shop painting.

### Motors

Name of manufacturer.

Type and model.

Type of bearings and method of lubrication.

Rated size of motor, hp.

Temperature rating.

Full load rotative speed.

Efficiency at full load and rated pump condition.

Full load current.

Locked rotor current.

1-3.01. Test Reports. Upon completion and testing of the installed system, test reports shall be submitted in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria. Each test report shall indicate the final position of controls.

1-3.02. Operation and Maintenance Manuals. Complete sets of instructions containing the manufacturer's operating and maintenance instructions for each piece of equipment shall be furnished. Each set shall be permanently bound and shall have a hard cover. One complete set shall be furnished at the time the tests procedure is submitted. Remaining sets shall be furnished no later than initial startup and testing. The following identification shall be inscribed on the covers: The words "OPERATING AND MAINTENANCE INSTRUCTIONS," name and location of the building, name of the Contractor, and contract number. Flysheets shall be placed before instructions covering each subject. Instruction sheets shall be approximately 8-1/2 by 11 inches, with large sheets of drawings folded in. Instructions shall include, but not be limited to, the following:

- a. System layout showing piping, valves, and controls;
- b. Approved wiring and control diagrams;
- c. A control sequence describing startup, operation, and shutdown;

- d. Operating and maintenance instructions for each piece of equipment, including lubrication instructions and troubleshooting guide;
- e. Manufacturer's bulletins, cuts, and descriptive data; and parts list and recommended spare parts.

1-3.03. Spare Parts Data. After approval of the detail drawings, and prior to the date of substantial completion, the Subcontractor shall furnish spare parts data for each different item of materials and equipment specified. Data shall include a complete list of parts and supplies, with source of supply.

## PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. The pumps shall be used to pump drainage, overflows, and washdown waters to the influent tank for treatment.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. The pump shall be designed for the following operating conditions and requirements:

The sump pump shall be heavy-duty, screenless, nonclog, column-type, and shall be Weil Model 2527 or equal. The pump shall come complete with a wall mounted single pole simplex float switch with integrated alarm (Weil Model 8231K6105 or equal) and a simplex control panel (Weil Model 8153 or equal).

Unit designation	P-100
Location	Treatment Building
Type	Simplex
Rated total head, feet	20
Capacity of each pump	
at rated head, gpm	200
Pump discharge size, in.	3
Max pump operating speed, rpm	1,750
Motor horsepower	2
Min size of solids, inches	2
Sump inside plan dimensions	3'0" x 3'0"
Sump depth, bottom of sump to underside of sump cover, feet	3'0"

Reference bottom of sump, El	49.6'
Sump liquid limits, El	
Pump start	51.5'
High Water Alarm	52.3'
Pumps stop	49.9'

For design and rating purposes, the liquid to be pumped shall be assumed to have a temperature of 85°F. Each pump shall be designed to operate with the suction set not less than 2 inches or more than 4 inches above the bottom of the sump. Pump performance shall be stable and free from cavitation and noise throughout the operating head range.

### 2-3. MATERIALS.

Pump Casing	Cast iron, ASTM A48.
Impeller	Cast iron, ASTM A48.
Shaft	Stainless steel, AISI Type 304, 316, or 416.
Shaft Bearing	Double sealed stainless steel ball bearing, AISI Type 304, 316, or 416.
Discharge Pipe	Schedule 80 PVC with flange adaptor

### 2-4. PUMP CONSTRUCTION.

2-4.01. Impeller. The impeller shall be a one-piece casting completely machined on all exterior surfaces and dynamically balanced.

The impeller shall be securely locked to the shaft so that it will not loosen during any condition of operation or handling, including reverse rotation, but shall be easily removable.

2-4.02. Shaft. Each shaft shall be machined or ground to size and polished. The shaft shall be of ample size to transmit the maximum applied power at the maximum operating head and to carry the hydraulic loads without excessive deflection.

2-4.03. Bearings. All axial impeller and shaft weight and thrust shall be carried by an axially adjustable thrust bearing mounted above the baseplate. The bearing shall have an AFBMA L<sub>10</sub> Life Rating of 20,000 hours at the maximum operating head. The bearing shall be sealed to retain grease and to prevent contamination. A grease fitting shall be provided in the bearing housing to permit lubrication of the bearing. The bearing housing and seals shall be arranged to purge old grease as new grease is added.

Each bearing located below the baseplate shall have internal lubrication grooves to ensure adequate lubrication of the entire running surface. A separate grease line, extending through and secured to the baseplate, shall be provided for each grease lubricated bearing.

2-4.04. Discharge Pipe. The discharge pipe shall be securely locked to the pump casing and the baseplate. The discharge outlet shall terminate above the baseplate in flanged connection.

2-4.05. Sump Cover. A sump cover that is sufficiently rigid to support a minimum of 300 pounds shall be provided by the subcontractor. The cover shall consist of a steel grate and shall not impede the flow of water into the sump. The cover shall be securely anchored to the concrete floor but shall be removable for inspection and maintenance of the pump. Sump cover dimensions and openings shall be located as indicated on the drawings.

The sump cover shall be provided with suitable gaskets to ensure gastight operation.

2-5. BALANCE. All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided.

## 2-6. DRIVE UNITS.

2-6.01. Motors. Electric drive motors shall conform to the requirements of the General Equipment Stipulations.

2-6.02. Motor Starters. Motor starters shall be furnished under the electrical section.

## PART 3 - EXECUTION



3-1. INSTALLATION. The pumps shall be installed as recommended by the pump manufacturer. The control system shall be adjusted as required to start and stop the pumps at the specified sump liquid levels.

3-2. TESTING. Sump pumps will be tested in accordance with Section 1400.

End of Section

## SECTION 11210

### SUBMERSIBLE WELL PUMPS

#### PART 1 - GENERAL

##### 1-1. GENERAL REQUIREMENTS.

1-1.01. Standard Products. Material and equipment shall as specified in this section.

1-1.02. Nameplates. Each pump shall have the manufacturer's name, address, type or style, model, serial number, and catalog number on a plate secured to the item of equipment.

1-1.03. Verification of Dimensions. The Subcontractor shall become familiar with all details of the work, verify all dimensions in the field and shall advise the Contractor of any discrepancy before performing the work.

##### 1-2. SUBMITTALS.

The following shall be submitted as follows:

1-2.01. Shop Drawings. Shop drawings shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Drawings shall show proposed layout in well vaults and anchorage of equipment appurtenances.

1-2.02. Test Reports. Upon completion and testing of the installed system, test reports shall be submitted in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria. Each test report shall indicate the final position of controls and pump setting depths in the wells.

1-2.03. Operation and Maintenance Manuals. Complete sets of instructions containing the manufacturer's operating and maintenance instructions for each piece of equipment shall be furnished in the site Operation and Maintenance manual. Instructions shall include, but not be limited to, the following:

- a. System layout showing piping, valves, and controls;

- b. A control sequence describing startup, operation, and shutdown;
- c. Operating and maintenance instructions for each piece of equipment, including lubrication instructions and troubleshooting guide;
- d. Manufacturer's bulletins, cuts, and descriptive data; and parts list and recommended spare parts.

## PART 2 - PRODUCTS

### 2-1. PUMP AND DRIVER REQUIREMENTS.

2-1.01. Type of Installation. The work shall include furnishing, installing, and testing electric pumping units and their appurtenances as indicated. Pumps shall be utilized for extraction of groundwater contaminated with low levels of VOCs or Dense non-aqueous phase liquids (DNAPL) as specified below. All groundwater extraction pumps shall be installed in and for installation in a vertical 6-inch diameter well.

**Table 1**  
**Groundwater Extraction Well Pump Performance**

Location	Pump Designation	Design Peak Flow (gpm)	Total Design Head at Peak Flow (ft. H <sub>2</sub> O)
W-1	RW-100	39	188
W-2	RW-101	37	157
W-3	RW-102	26	92
W-4	RW-103	14	109
W-5	RW-104	14	122
W-6	RW-105	14	129
W-7	RW-106	33	137
W-8	RW-107	33	161

All product recovery pumps shall be installed in and for installation in a vertical 4-inch diameter well.

Location	Pump Designation	Design Peak Flow (gpm)	Total Design Head at Peak Flow (ft. H <sub>2</sub> O)
PRW-1	PRW-100	0.3	100
PRW-2	PRW-101	0.3	100
PRW-3	PRW-102	0.3	100

2-1.02. Pump Drivers. Pumps shall be electrically driven.

2-2. SUBMERSIBLE GROUNDWATER RECOVERY PUMP SYSTEM.

Submersible groundwater recovery pumps shall be as follows or equivalent:

At location W-2 and W-8 - **Grundfos Model 40S30-9** or equal

- Bottom-loading intake with inlet strainer
- 3 hp Franklin single phase 230V/60Hz three wire motor
- 2 inch NPT discharge connection
- 304 AISI stainless steel outer casing and internals with Teflon seals
- Built-in sand bearing to minimize sand damage
- Serviceable jam-free stainless steel check valves
- Built-in support cable guard
- Five (5) year warranty (3 @ 100%, 2 @ 50%)

Additional associated hardware shall include the following:

- 90' two wire (with ground) insulated leads
- 2" ID 304AISI stainless steel discharge piping with stainless clamps
- Downwell torque arrestor (stainless steel)
- 3/16" Stainless support cable with quick-link
- 6" Diameter SCH40 carbon steel locking well cap (non-pressure).

At location W-1 - **Grundfos Model 60S50-7** or equal

- Bottom-loading intake with inlet strainer
- 5 hp Franklin single phase 230V/60Hz three wire motor
- 2 inch NPT discharge connection

- 304 AISI stainless steel outer casing and internals with Teflon seals
- Built-in sand bearing to minimize sand damage
- Serviceable jam-free stainless steel check valves
- Built-in support cable guard
- Five (5) year warranty (3 @ 100%, 2 @ 50%)

Additional associated hardware shall include the following:

- 90' two wire (with ground) insulated leads
- 2" ID 304AISI stainless steel discharge piping with stainless clamps
- Downwell torque arrestor (stainless steel)
- 3/16" Stainless support cable with quick-link
- 6" Diameter SCH40 carbon steel locking well cap (non-pressure).

At location W-7 - **Grundfos Model 40S20-7** or equal

- Bottom-loading intake with inlet strainer
- 2 hp Franklin single phase 230V/60Hz three wire motor
- 2 inch NPT discharge connection
- 304 AISI stainless steel outer casing and internals with Teflon seals
- Built-in sand bearing to minimize sand damage
- Serviceable jam-free stainless steel check valves
- Built-in support cable guard
- Five (5) year warranty (3 @ 100%, 2 @ 50%)

Additional associated hardware shall include the following:

- 90' two wire (with ground) insulated leads
- 2" ID 304AISI stainless steel discharge piping with stainless clamps
- Downwell torque arrestor (stainless steel)
- 3/16" Stainless support cable with quick-link
- 6" Diameter SCH40 carbon steel locking well cap (non-pressure).

At locations W-3 and W-5 - **Grundfos Model 25S07-5** or equal

- Bottom-loading intake with inlet strainer
- 0.75 hp Franklin single phase 230V/60Hz three wire motor
- 1.5 inch NPT discharge connection
- 304 AISI stainless steel outer casing and internals
- Built-in sand bearing to minimize sand damage
- Serviceable jam-free stainless steel check valves
- Built-in support cable guard
- Five (5) year warranty (3 @ 100%, 2 @ 50%).

Additional associated hardware shall include the following:

- 75' two wire (with ground) insulated leads
- 1.5" ID 304AISI stainless steel discharge piping with stainless clamps

- Downwell torque arrestor (stainless steel)
- 3/16" Stainless support cable with quick-link
- 6" Diameter SCH40 carbon steel locking well cap (non-pressure).

At location W-4 - **Grundfos Model 16S05-5** or equal

- Bottom-loading intake with inlet strainer
- 0.5 hp Franklin single phase 230V/60Hz three wire motor
- 1.25 inch NPT discharge connection
- 304 AISI stainless steel outer casing and internals
- Built-in sand bearing to minimize sand damage
- Serviceable jam-free stainless steel check valves
- Built-in support cable guard
- Five (5) year warranty (3 @ 100%, 2 @ 50%).

Additional associated hardware shall include the following:

- 75' two wire (with ground) insulated leads
- 1.25" ID 304AISI stainless steel discharge piping with stainless clamps
- Downwell torque arrestor (stainless steel)
- 3/16" Stainless support cable with quick-link
- 6" Diameter SCH40 carbon steel locking well cap (non-pressure).

At location W-6 - **Grundfos Model 40S15-5** or equal

- Bottom-loading intake with inlet strainer
- 1.5 hp Franklin single phase 230V/60Hz three wire motor
- 2 inch NPT discharge connection
- 304 AISI stainless steel outer casing and internals
- Built-in sand bearing to minimize sand damage
- Serviceable jam-free stainless steel check valves
- Built-in support cable guard
- Five (5) year warranty (3 @ 100%, 2 @ 50%).

Additional associated hardware shall include the following:

- 75' two wire (with ground) insulated leads
- 2" ID 304AISI stainless steel discharge piping with stainless clamps
- Downwell torque arrestor (stainless steel)
- 3/16" Stainless support cable with quick-link
- 6" Diameter SCH40 carbon steel locking well cap (non-pressure).

## 2-3. SUBMERSIBLE PRODUCT RECOVERY PUMP SYSTEM.

Submersible product recovery pumps shall be as follows or equivalent:

At all locations – **Clean Earth Technologies Magnum Spill Buster System** or equal

- Bottom-loading intake with inlet strainer
- 230V/60Hz Single phase 100 watt motor
- 304 AISI stainless steel casing and internals with Teflon seals
- Built-in sand bearing to minimize sand damage
- Serviceable jam-free stainless steel check valves
- Built-in support cable guard
- Five (5) year warranty (3 @ 100%, 2 @ 50%)

Additional associated hardware shall include the following:

- 100' Control/power cables
- Integrated epoxy DNAPL sensor array
- Pump controller
- 100' Long Teflon discharge tubing with stainless clamps
- 4" Diameter SCH40 carbon steel locking well cap (non-pressure).

## 2-4. ELECTRICAL EQUIPMENT.

2-4.01. Controls. Water level sensors for groundwater extraction well pumps shall be of the conductivity type and shall be set at appropriate depths so as to minimize cycling of the pump while ensuring a consistent flow of water at the specified flow rate. Manufacturer shall be Warrick Controls or equivalent. Sensors shall include the following:

- Conductivity Probe High (water level high switch) - activates pump upon immersion in water.
- Conductivity Probe Low (water level low switch) - deactivates pump when water falls below this level.
- Conductivity Probe Low-Low (water level low-low switch) - when water level falls below this level, pump and other process equipment are deactivated, an alarm light is illuminated on the treatment system control panel, and a remote alarm is initiated.
- Conductivity Probe Common (conductivity relative ground) - must remain submerged to provide reference conductivity level.

Controllers for product recovery wells shall be part of a complete pumping system and shall be provided by the same manufacturer as the pump.

## 2-5. EQUIPMENT APPURTENANCES.

2-5.01. Attachments. All necessary bolts, nuts, washers, bolt sleeves, and other types of attachments for the installation of the equipment shall be furnished with the equipment. Bolts shall conform to the requirements of ASTM A 307 and nuts shall be hexagonal of the same quality as the bolts used. Threads shall be clean-cut and shall conform to ANSI B1.1.

Bolts, nuts, and washers specified to be galvanized or not otherwise indicated or specified, shall be zinc coated after being threaded, by the hot-dip process conforming to ASTM A 123 or A 153 as appropriate. Bolts, nuts, and washers specified or indicated to be stainless steel shall be Type 316.

2-5.02. Special Tools. A complete set of all special tools which may be necessary for the adjustment, operation, maintenance, and disassembly of all equipment shall be furnished. Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment. Tools shall be high-grade, smooth, forged, alloy, tool steel. Special tools shall be delivered at the same time as the equipment to which they pertain. The Subcontractor shall properly store and safeguard such special tools until completion of the work, at which time they shall be delivered to the Contracting Officer.

### PART 3 - EXECUTION

#### 3-1. INSTALLATION.

Each pump shall be installed in accordance with the written instructions of the manufacturer.

#### 3-2. TESTING.

3-2.01. Factory Pump Test. None required

3-2.02. Field Pump Test. After installation of the pumping units, discharge piping, and appurtenances is complete, operating tests shall be performed. Each pumping unit shall be given a running field test in the presence of Contractor for a minimum of 1/2 hour. Each pumping unit shall be operated at its rated capacity or such other point on its head-capacity curve selected by the Contractor.

The Subcontractor shall provide an accurate and acceptable method of measuring the discharge flow. Tests shall assure that the units and appurtenances have been installed correctly, that there is no objectionable vibration, or noise from any parts, and that all manual and automatic controls function properly.

If any deficiencies are revealed during any tests, such deficiencies shall be corrected to the satisfaction of the Contractor and the tests shall be reconducted.

End of Section



SECTION 11430  
GROUNDWATER TREATMENT SYSTEM – PERFORMANCE SPECIFICATIONS

PART 1 - GENERAL

1-1. SCOPE.

This section covers the groundwater treatment process system necessary to remove volatile organic compounds (VOCs) and other contaminants from extracted groundwater. This section specifies minimum requirements for the process equipment elements of the selected process, required equipment for the process as well as installation and testing specifications.

A process control description is included in Section 16901. Interconnecting piping and wiring are specified in DIVISION 15 - MECHANICAL and DIVISION 16 - ELECTRICAL, respectively. Instrumentation is also specified in DIVISION 16 - ELECTRICAL.

1-2. TREATMENT PROCESS PERFORMANCE REQUIREMENTS.

Generally, extracted groundwater from the wells shall be routed to the influent holding tank for subsequent treatment. The treatment process system shall include the following: an initial filtration system with two bag filters to remove insoluble material from the aqueous phase of process water pumped from the influent tank; an air stripper system to remove VOCs from the process water; a pre-air stripper hardness conditioning unit (if necessary) to minimize the formation of scale and other mineral build-up on the air stripper system; a secondary filtration system with two bag filters to remove insoluble material from the process water pumped from the air stripper; two post-air stripper liquid phase granular activated carbon (LGAC) units in series to remove VOCs from the process water; a LGAC backwash system that discharges backwash water to the system influent tank; two vapor phase granular activated carbon (VGAC) units in series to remove VOCs for the air stripper discharge gas; an effluent holding tank; and a discharge system to route treated water to the Red Lion Creek. The treatment system shall include all pumps, valves, instrumentation, piping, control systems and electrical wiring needed to form a complete and functional treatment system capable of meeting the performance requirements specified herein as well as those in all other applicable specification sections.

A likely layout for the treatment process is shown in the process flow diagrams included in the subcontract drawings.

The treatment system shall be capable of processing no less than 158 gallons per minute (gpm) at all times while operating and shall allow for expansion to treat additional flow as required.

The treatment system shall be constructed so as to operate continuously for fifteen to thirty years with a minimum annual run time percentage of 95% for any given year. This run time will be calculated based on the total number of hours that the system operates in a given year divided by the total number of hours in that given year. Unless otherwise specified by the Contractor, the system will only be considered to be operating when it is meeting the prescribed discharge limits set herein and processing extracted groundwater at a rate at least equal to the maximum sustainable extraction rate achievable by the treatment system extraction well pumps but not greater than 158 gpm.

The estimated influent water quality shown in Table 1 is based on data obtained from various groundwater monitoring wells on the SCD site. Using this data, a composite average of each parameter was developed for the site. The actual influent contaminant levels will be dependent on the quality and volume of water actually pumped from the system's recovery wells. Consequently, a sample shall be collected from the proposed recovery well location (at the proposed recovery well pump depth) and analyzed for VOCs and metals. The results of this sample shall be used in conjunction with the values given on Table 1 to make a final determination of the projected influent water quality.

Regardless of influent water quality, the treatment system must achieve all metal specific and compound specific limits listed in its National Pollutant Discharge Elimination System (NPDES) permit equivalent to allow the treated water to be discharged to the Red Lion Creek. For any organic compound or inorganic constituent that does not have a specific limit listed in the treatment system's NPDES permit equivalent, the system shall achieve a minimum removal rate sufficient to ensure that the effluent concentration of that compound is less than its respective National Drinking Water Standards Maximum Contaminant Level (MCL). The treatment system shall also be constructed and maintained so as to comply with all other conditions listed in its NPDES permit equivalent, its Delaware Department of Natural Resources and Environmental Control (DNREC) air permit equivalency, and all applicable conditions and regulations contained in Title 7 of the Delaware Code.

<b>Compound</b>	<b>Estimated Average System Influent Concentration (: g/l)</b>	<b>Estimated NPDES Average Monthly Effluent Limits<sup>1</sup> (: g/l)</b>	<b>Estimated NPDES Daily Maximum Effluent Limits<sup>1</sup> (: g/l)</b>
Benzene	18,100	5	NA
Chlorobenzene	30,000	100	NA
Nitrobenzene	1,500	2,237	NA
Toluene	1	28	NA
1,2-Dichlorobenzene	14,900	196	NA
1,3-Dichlorobenzene	1,700	142	NA
1,4-Dichlorobenzene	11,700	75	NA
1,2,4-Trichlorobenzene	4,200	70	NA
1,2,3-Trichlorobenzene	1,100	NA	NA
1,3,5-Trichlorobenzene	1,000	NA	NA
1,2,3,4-Tetrachlorobenzene	692	NA	NA
1,2,4,5-Tetrachlorobenzene	438	NA	NA
Pentachlorobenzene	120	NA	NA
Hexachlorobenzene	1	1	NA
Iron (total)	NA	2,000	3,000
Lead	NA	150	230
Aluminum	NA	NA	NA
Arsenic	NA	NA	NA
Cadmium	NA	NA	NA
Chromium (total)	NA	150	230
Copper	NA	1.2	2.9
Nickel	NA	NA	NA
Zinc	NA	64	95

ND – Non-detect

NA – Not Available

Note 1 – All limiting discharge concentrations shall be in accordance with the system's NPDES permit.

The treatment system shall also reduce the total VOC concentration and the concentrations of individual VOCs in the system's air emissions to levels equal to or less than the respective limits as listed in the DNREC Air Quality Permit for the treatment system. The treatment system shall also be constructed and maintained so as to comply with all other conditions listed in DNREC Air Quality Permit for the system and all applicable regulations contained in Title 7 of the Delaware Code.

1-3. GENERAL EQUIPMENT STIPULATIONS AND SUBCONTRACTOR RESPONSIBILITIES.

The Subcontractor shall furnish, transport, unload, install, connect, and test all of the equipment, pumps, wiring, and controls associated with the treatment process system.

All equipment furnished shall be provided as a single, complete, fully-engineered integrated system by a manufacturer/vendor who has fabricated successfully performing treatment systems similar to that specified herein for not less than two years prior to bid opening.

To the maximum extent practical, items of equipment shall be the manufacturer's standard products. To the extent practical, equipment shall be fabricated, assembled and tested in the shop to minimize installation and setup time at the treatment building.

The system shall include all necessary accessories and appurtenances to form a complete and functional system.

All treatment system process equipment shall be fabricated to operate in an aboveground, upright position.

All treatment system process equipment shall be electric driven such that flammable or explosive materials will not be necessary inside or immediately outside the treatment building. Electric motors shall be provided at each location requiring mechanical activity such that belt, pulleys, chain, and drive shafts shall not exist between each process equipment piece.

The Subcontractor is responsible for locating inlet/outlet flanges as well as process control sensors on all equipment so that the system may be arranged to make efficient use of space. Excess or unnecessary piping shall be kept to a minimum.

Equipment arrangement within the treatment building shall be generally as shown on the drawings, unless an alternate arrangement is proposed and approved by Contractor. Equipment shall be designed to fit within the space allocated within the 50 foot by 40 foot treatment building as shown on the drawings. Equipment design, installation and arrangement shall allow adequate access for maintenance and removal of equipment.

1-3.01. Process Piping and Valving. Process and chemical feed piping and valving shall be provided and installed in accordance with DIVISION 15 - MECHANICAL. Process piping shall accomplish the functions shown on the subcontract drawings.

1-3.02. Nameplates. Each major item of equipment shall have the manufacturer's name, address, serial and model number on a plate securely attached to the item. Additional operational information such as horsepower, capacity, etc. shall also be included. The plate shall be located in an area readily accessible/visible by plant personnel.

1-3.03. Workmanship. All parts of the mechanisms shall be amply proportioned for all stresses that may occur during fabrication, transportation, erection and intermittent or continuous operation.

1-3.04. Special Tools. Special tools necessary to the proper operation and maintenance of the equipment shall be furnished by the Subcontractor.

#### 1-4. DELIVERY AND STORAGE.

All equipment delivered and placed in storage shall be stored with protection from the weather, humidity, temperature variations, dirt, dust, and other contaminants as well as theft and/or vandalism.

#### 1-5. SPARE PARTS.

Spares shall be provided for parts as required in this specification. Spare parts shall be stored in a designated area within the treatment building. Spare parts shall be new and unused and shall be labeled and packaged appropriately for long term storage.

## 1-6. SUBMITTALS.

1-6.01. Vendor Certification. As part of its Bid, the Subcontractor shall submit certification and evidence that the vendor of the treatment process package has successfully fabricated and assembled similar packages for no less than two years prior to bid opening. Included in that submittal shall be the name, address and telephone number of at least three clients who have similar facilities in the United States that were furnished by the vendor. The references will be contacted for verification.

1-6.02. Shop Drawings. Before starting installation of any materials or equipment, the Subcontractor shall submit material lists, shop drawings, catalogue numbers, assembly drawings, and such other descriptive data to demonstrate compliance with the subcontract documents. Shop drawings shall include detailed plans of the equipment and piping and diagrams indicating interconnecting piping and all electrical wiring and electrical connections. Shop drawings for the treatment system shall be submitted as a comprehensive package at one time.

As a minimum, the Subcontractor shall furnish the following drawings and data:

### System Power Requirements

#### Influent Holding Tank (T-500)

- Tank dimensions
- Materials and details of construction
- Inlet/outlet sizes and locations

#### Bag Filters (F-500-1A, F-500-1B, F-500-2A, and F-500-2B)

- Dimensions
- Materials and details of construction (interior and exterior)
- Inlet/outlet sizes and locations
- Type and makeup of coatings
- Materials and details of filter material

#### Air Stripper (AS-500)

- Dimensions
- Materials and details of construction

Inlet/outlet sizes and locations  
Materials and details of system blower  
Electrical Requirements

Air Stripper Blower (B-1000)

Liquid Phase Carbon Units (C-1000 and C-1100)

Dimensions  
Materials and details of construction  
Inlet/outlet sizes and locations  
Pressure ratings  
Materials and details of carbon media

Vapor Phase Carbon Units (C-500 and C-501)

Dimensions  
Materials and details of construction  
Inlet/outlet sizes and locations  
Pressure ratings  
Materials and details of carbon media

Effluent Holding Tank (T-1200)

Dimensions  
Materials and details of construction  
Inlet/outlet sizes and locations

Probes and Controls

Identification/location  
Probe materials and details of manufacturer  
Controller input/output and programming information  
Probe and controller connection and mounting details

Metering Pumps and Chemical Feed Systems (CM-500)

Base and pump dimensions  
Pump type  
Materials and details of construction

- System capacities
- Flow rates
- Size, make and type of electrical motor
- Inlet/outlet sizes and locations
- Electrical Requirements

Access Platforms

- Arrangement and member sizes
- Materials and details of construction
- Grating specifications and layout

Sump Pump (P-100)

- Dimensions
- Materials and details of construction
- Inlet/outlet sizes and locations
- Performance specifications
- Electrical Requirements

Process and Backwash Pumps (P-500A, P-500B, P-1100A, P-1100B, P-1500)

- Dimensions
- Materials and details of construction
- Inlet/outlet sizes and locations
- Performance specifications
- Electrical Requirements

1-6.03. Spare Parts Data. The Subcontractor shall furnish a complete list of parts and supplies necessary for maintenance.

1-6.04. Test Plan and Reports. As a part of the Subcontractor's shop drawing submittal, a detailed testing and startup plan shall be submitted. This test plan shall include a schedule for testing, sample collection locations and frequency of collection, the equipment to be used for sampling and recording data, and a list of suggested laboratories for sample analysis. The Subcontractor shall coordinate the testing program with the state and federal regulatory agencies to dispose of any treated effluent from testing that does not meet discharge permit values and for the disposal of sludges generated during testing.



Upon completion and testing of the installed system, test reports shall be submitted in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria.

1-6.05. Operation and Maintenance Manuals. As required in the submittals section, the Subcontractor shall submit complete copies of instructions outlining the step-by-step procedures required for system startup, operation, and shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. In addition, the Subcontractor shall submit complete copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The instructions shall include wiring and control diagrams for the system as installed.

1-6.06. Treatment Chemical Data. The Subcontractor shall submit a list of all treatment chemicals, equipment cleansers/disinfectants, and other system-related chemicals proposed for use with the treatment system.

#### 1-7. OPERATOR TRAINING AND INSTRUCTION.

The Subcontractor shall prepare and conduct a training course for the purpose of instructing personnel designated by the Subcontractor in the maintenance and operation of the groundwater treatment system. The Subcontractor shall provide the services of the major process and control package vendor and/or manufacturers' representative(s) prior to or during the 14-day Field Performance Test to conduct the training.

The training course shall include instruction for start-up, routine operation and shut-down of the treatment system, as well as normal equipment and control maintenance procedures and control system and components adjustment and calibration procedures. The training course shall also include instruction for proper operator response to all alarm conditions and emergency shut-down conditions.

The Subcontractor shall provide each participant with a course notebook which outlines all materials and procedures presented during the training course. Course notebooks shall be based on the operation and maintenance manuals and shall be submitted to the Contractor for approval not less than 10 days prior to the training course.

## 1-8. WARRANTIES/GUARANTEES.

The Subcontractor shall guarantee that upon completion of all testing and calibration, the groundwater treatment system will meet all performance criteria described in this specification. If modifications to the treatment system including equipment or control modification or addition or substitution of equipment are necessary to satisfy the stated performance criteria, the Subcontractor shall make such modifications, substitutions or additions at no additional cost.

The Subcontractor shall warranty the proper operation of equipment and the water treatment performance of the process for a period of 30 months following satisfactory completion and acceptance by Owner of all field testing and short-term operation. During this warranty period, at no additional cost to the Contractor or Owner, the Subcontractor shall repair or replace any defective equipment and shall provide any necessary calibration, adjustment or equipment replacement necessary to bring the treatment process into full compliance with the stated performance criteria.

## PART 2 - PRODUCTS

### 2-1. MATERIALS AND EQUIPMENT.

Materials and equipment shall be as proposed by Subcontractor and as shown in the drawings, and shall be suitable for the service intended. Materials and equipment shall be new and unused, except for tests. Where two or more pieces of equipment perform the same or similar functions are required, they shall be duplicate products of the same manufacturer.

Tanks and vessels supplied by the Subcontractor shall operate at atmospheric pressure, and at temperatures ranging from 50°F to 130°F. All tanks shall have means to locally indicate the level of liquids in the tanks.

2-1.01. Materials. Unless otherwise specified, all materials shall be in accordance with the following:

#### Steel

Shapes, Plates, and Bars

ASTM A 36.

Sheets

ASTM A 366 or A 569, zinc coated.

Pipe	ASTM A 120 or A 53.
Bolts and nuts	ASTM A 307.
Nuts, Self-Locking	Prevailing torque type; IFI-100, Grade A.
Washers	
Flat	ANSI B18.22.1.
Lock	ANSI B18.21.1, helical spring type.

#### Aluminum

Sheet and Plate	ASTM B209, alloy 6061-T6.
Rolled Sections	ASTM B308, alloy 6061-T6.
Rod and Bar	ASTM B211, alloy 6061-T6 or 2017-T4.
Extrusions	ASTM B221, alloy 6063-T5 or T6.

#### Stainless Steel

Shapes and Bars	ASTM A276, Type 316L.
Plates	ASTM A167, Type 316L.
Piping	ASTM A312, Grade TP304L or TP316L
Bolts and Nuts	IFI-100, Grade 303, 304, or 305.
Washers, Flat	ANSI B18.22.1.
Thread Lubricant	John Crane "Thread Gard Nickel" or equal.

#### Fiberglass-Reinforced Plastic

Resin	Isophthalic polyester resin with ultraviolet inhibitor.
Reinforcing	Glass fiber with a suitable coupling agent (ASTM D2996 and ASTM D3299).

#### High Density Polyethylene (HDPE)

Material	ASTM D3350
Pipe/Fittings	ASTM F714

#### Polyvinyl Chloride (PVC)

Material	ASTM D1784
Fittings	ASTM D2464 and ANSI B16.5

#### Polypropylene (PPL)

Material  
Pipe/Fittings

ASTM D3350  
ASTM F714-90

2-2. EQUIPMENT. The following subsections specify details of the process equipment that shall be provided. General information for major equipment items is specified in the equipment data sheets at the end of the section. Where typical equipment manufacturers and model numbers are listed on the data sheets, it shall be understood that the words "or equal" following the enumeration, if not specifically stated, are implied.

Table 2 is a list of process equipment items including equipment designations that were used to design the building and support facilities. Some items in Table 2 are specified in other sections of these specifications. An adequate number of sampling ports shall be provided (either incorporated into the process equipment or on the transfer piping) to ensure that all portions of the treatment system are functioning properly and that all air and liquid discharges meet their respective permit limits. All instrumentation, gauges, meters, and control systems shall be integrated with the overall treatment system control and monitoring system and allow for remote monitoring of system operating conditions.

<b>Table 2 Equipment Designation Standard Chlorine of Delaware</b>	
<b>Unit</b>	<b>Designation</b>
Influent Holding Tank	T-500
Influent Pump	P-500A, P-500B
Influent Bag Filter	F-500-1A, F-500-1B
Metals Removal Process Effluent Pump	P-1000A, P-1000B
Sequestering Chemical Metering Pump	CM-500
Air Stripper	AS-500
Air Stripper Bag Filter	F-500-2A, F-500-2B
Air Stripper Effluent Pump	P-1100A, P-1100B
Liquid Phase Carbon Units	C-1000; C-1100
Effluent Holding Tank (temporary)	T-1200
Effluent Tank Pump (as needed)	P-1500
Sump Pump	P-100
Well Pump	RW-100; RW-101; RW-102; RW-103; RW-104; RW-105; RW-106; RW-107
Vapor Phase Carbon Units	C-500; C-501

If the Subcontractor furnishes alternative physical process equipment that differs from these requirements, then the building and support facilities shall be modified as necessary. Modifications shall be approved by the Contractor and shall be made at no additional cost to Contractor or Owner.

#### 2-2.01. Influent Holding.

2-2.01.01. Process Description. Extracted groundwater from the extraction wells shall be pumped to the influent holding tank T-500. Extracted groundwater shall be accumulated in the influent holding tank to provide a steady supply of process water for the treatment system.

2-2.01.02. Assembly/Construction. T-500 shall be a vertical, cylindrical, closed topped tank constructed of epoxy coated steel. Groundwater will be piped to the tank where it will enter the tank through fittings on the top. The tank will have access ports sufficient to allow routine cleaning and maintenance of the tank. The tank shall be equipped with a discharge port located approximately six inches above the bottom and an overflow port located approximately two inches below the top of the tank sidewall. In addition, the tank shall be equipped with a drain port and a sludge clean-out port each located approximately two inches above the bottom of the tank sidewall. The tank shall have an operating volume of 5,000 gallons.

#### 2-2.02. Solids/Organics Removal.

2-2.02.01. Process Description. Process water from the influent holding tank shall be pumped through bag filters (in parallel) for mass solids removal. Following the solids removal process, a sequestering agent shall be added to the water (to prevent the formation of scale) and the water shall be pumped to a low profile air stripper where VOCs will be volatilized and removed. After the air stripper, process water shall be fed through a second set of bag filters (two in parallel) to remove any biological growth and/or suspended solids. The water shall then be pumped through the carbon units for further removal of VOCs before flowing to the effluent holding tank.

Process water from the effluent holding tank shall be pumped to the Red Lion Creek. Following the initial start-up and prove out of the treatment system, the effluent holding tank may be removed and the process water pumped directly from the carbon units to the

discharge point.

#### 2-2.02.02. Assembly/Construction.

##### Bag Filters (F-500-1A, F-500-1B; F-500-2A, F-500-2B)

The Subcontractor shall select, design, install, and operate two solids removal processes (bag filters) that will prevent or minimize plugging of the air stripper and the carbon vessels. Two bag filters will occur upstream of the air stripper (directly before the sequestering agent system) and be operated in parallel. An additional two bag filters (also operating in parallel) will occur upstream of the first carbon unit, respectively. The bag filter housing model shall be the 30-inch Kristil Klear model 88 (or equivalent), shall be constructed of AISI 304 or 316 stainless steel, rated at 150 pounds per square inch (psi), and shall provide 4.4 square foot of filter surface area. Piping and controls shall allow the operator to bypass one or both bags during filter media changeouts. The differential pressure across each bag filter assembly shall be monitored and transmitted by the use of Barksdale model DPD1T-A80SS differential pressure switches (or equivalent) mounted to the exterior of the bag filter housings.

##### Sequestering Agent System

The Subcontractor shall design, install, and operate a sequestering agent (Calsperse 500 or equivalent) addition system to prevent/limit the formation of scale in the treatment system process equipment. The addition system shall include a chemical storage tank, a metering pump, and all necessary controls to ensure proper operation and minimization of scale formation.

##### Air Stripper (AS-500)

The Subcontractor shall design, install and operate a low-profile air stripper complete with blower, sump, and all instrumentation and controls necessary to achieve a minimum 99.9% removal of each of the VOCs present in the process water. The air stripper shall be designed with a minimum air to water (A/W) ratio of 109 and shall be designed to enable the Contractor or Subcontractor to modify the system to increase VOC removal efficiencies via the installation of additional aeration trays (or equivalent units). The system shall be a Carbonair model STAT 720 (or equivalent) incorporating at least 4 stainless steel aeration

trays, a stainless steel sump and a stainless steel demister section (or an equivalent system). The system shall incorporate a **Rotron** (or equivalent) regenerative blower capable of generating 3,500 scfm at 65-inches water column, a **Rotron** (or equivalent) air flow meter, and a **Dwyer model 1950-5** (or equivalent) low pressure switch. The blower shall also have an inlet filter (with a replaceable element) to minimize the introduction of airborne particulates from the surrounding airspace. The system shall include high, high-high, low, and low-low level switches and all associated controls to monitor and maintain appropriate water levels within the stripper. The system shall also include a high pressure switch to identify possible fouling of the air stripper and a low pressure switch to identify potential blower malfunctions.

#### Liquid Phase Carbon Vessels (C-1000 and C-1100)

The Subcontractor shall design and install two skid-mounted LGAC vessels (Carbonair model PC-28 or equivalent), each containing 5,000 pounds of virgin carbon, in series as the secondary organics removal technology. Each vessel shall include a pressure relief valve (Kunkle **model 20-E01-MG** or equivalent) set to prevent damage to the vessel in the event of a buildup of pressure within the vessel. Piping and controls for the two vessels shall enable the Contractor to bypass one or both vessels (for backwash, cleaning, and carbon replacement purposes), operate the vessels in series (projected primary operation mode) with either vessel as the first in the series, and operate them in parallel. A backwash system (using the building's potable water supply) capable of removing any accumulated solids from the carbon beds shall be included with the system and shall be piped to allow discharge of the backwash water to the treatment system's influent holding tank. The backwash system will automatically backwash the filter media based on an increase in system backpressure beyond a limit to be determined by the Subcontractor. Inlet and outlet pressure gauges (Manufacturer Ashcroft or equivalent) shall be mounted on each vessel to monitor vessel operating conditions and shall be wired to transmit readings to the main treatment system controller. Sample ports shall be provided at the influent and at the effluent of each carbon vessel.

#### Vapor Phase Carbon Vessels (C-500 and C-501)

The Subcontractor shall design and install two skid-mounted VGAC vessels (Carbonair model GPC-120 or equivalent), each containing 13,600 pounds of virgin carbon, in series as the secondary organics removal technology. Each vessel shall include a pressure relief valve

(Kunkle model 20-E01-MG or equivalent) set to prevent damage to the vessel in the event of a buildup of pressure within the vessel. Piping and controls for the two vessels shall enable the Contractor to bypass one or both vessels (for cleaning and carbon replacement purposes), operate the vessels in series (projected primary operation mode) with either vessel as the first in the series, and operate them in parallel. Inlet and outlet pressure gauges (Manufacturer Ashcroft or equivalent) shall be mounted on each vessel to monitor vessel operating conditions and shall be wired to transmit readings to the main treatment system controller. Sample ports shall be provided at the influent and at the effluent of each vessel.

### Duct Heater

A duct heater shall be properly sized and installed upstream of the vapor phase carbon vessels and downstream of the air outlet of the air stripper. The duct heater shall be a Groupe B Limited 5 kW single stage Model HX-2000 (or equivalent) and shall be capable of achieving a minimum delta T of 20°F and an exhaust relative humidity of 50% at an air flow rate of 3,500 cfm. The duct heater shall be equipped with intake and exhaust thermometers and shall energize and power down the heating elements automatically to maintain a constant set point temperature. Duct work between the air stripper and the vapor phase carbon units shall be of a material capable of withstanding the temperatures generated by the duct heater and shall be sufficiently insulated so as to minimize heat loss and the potential for worker injury.

### 2-2.03. Effluent Holding.

2-2.03.01. Process Description. Effluent from the treatment system shall be accumulated in a temporary effluent holding tank (T-1200) for primary discharge to the Red Lion Creek. In addition, a recirculation line will be installed to the influent tank to enable closed loop operation of the plant, as necessary. Treated process water shall be pumped from the effluent holding tank to the Red Lion Creek at a rate of 158 gpm via a four-inch PVC discharge line.

2-2.03.02. Assembly/Construction. The effluent holding tank shall be a vertical, cylindrical tank constructed of fiberglass-reinforced plastic. The tank will have access ports sufficient to allow routine cleaning and maintenance of the tank. The tank shall be equipped with a discharge port located approximately six inches above the bottom of the tank sidewall. In addition, the tank shall be equipped with a drain port and a sludge clean-out port each



located approximately two inches above the bottom of the tank sidewall. The tank shall have an operating volume of 5,000 gallons.

2-2.03.03. Discharge Monitoring. The volume of treated water from the effluent holding tank shall be metered with a flow totalizing meter located on the storm sewer discharge line. The flow totalizing meter shall be wired to transmit readings to the main treatment system controller. Sampling ports shall be provided to allow sampling and analysis of the system effluent as required by the system's NPDES permit and elsewhere in this specification.

2-2.04. Discharge Energy Dissipation Feature. Reno mattresses will be placed at the discharge line outfall to ensure that any wetland impacts related to the force of the treated water discharge are minimized to the maximum extent practicable.

### PART 3 - EXECUTION

3-1. INSTALLATION. All equipment shall be leveled, plumbed, and aligned into position. Installation procedures shall be as recommended by the equipment manufacturer. Materials and equipment shall be prepared for service as indicated and as recommended by the manufacturer.

The equipment (where applicable) shall be adequately lubricated and lubrication reservoirs filled before testing, startup and operation.

3-2. TESTING. After installation of the equipment, the Subcontractor shall conduct startup and operating tests to demonstrate that the equipment will operate in accordance with all specified requirements. Details of the test durations, sampling requirements, discharge options, etc., during these tests shall be discussed in the Subcontractor's O&M Plan.

3-2.01. System Startup Testing.

3-2.01.01. Tanks and Piping. All tanks and vessels shall be hydrostatically tested with potable water prior to any operational tests. The tanks shall be filled with water for a period of 24 hours and inspected for leaks. Any leaks shall be repaired by the Subcontractor. All process piping shall be tested in accordance with DIVISION 15 - MECHANICAL.

3-2.01.02. Potable Water Operational Testing. Following completion of the hydrostatic

testing of the tanks and piping, Subcontractor shall operate the system for a period of five (5) days (8 hours/day) in a closed loop manner using potable water. The system shall be staffed during the entire duration of this test. This closed-loop startup testing shall be conducted using a 158 gpm flow rate.

Tests shall demonstrate that the equipment is not electrically, mechanically, structurally, or otherwise defective; is in safe and satisfactory operating condition; and conforms with the specified operating characteristics. Tests shall include checks for excessive vibration, leaks in all piping and seals, correct operation of control systems and equipment, proper alignment, excessive noise levels, and power consumption.

The Subcontractor shall realign or replace any equipment that does not perform or does not pass system testing. All deficiencies shall be corrected by the Subcontractor at his own cost.

### 3-2.02. Field Performance Test.

3-2.02.01. General. After the successful completion of the tests conducted by the Subcontractor to demonstrate the operation of the equipment, a Field Performance Test shall be performed demonstrating that the operation of the groundwater treatment system meets all requirements of PARAGRAPH 1-2 of this specification. The field performance test shall consist of the following three separate phases:

- First the Subcontractor will pump groundwater from the extraction wells through the treatment system. The treated groundwater will be discharged into temporary, onsite storage tanks (Baker/Frac tanks) for daily analytical testing. Treated groundwater will be discharged into the permitted discharge point once testing results indicate the water meets the appropriate NPDES discharge limits/surface water criteria. Weekly monitoring/sampling shall be performed to ensure that the system's air emissions are in accordance with the system's DNREC air permit. Subcontractor shall operate the system in this fashion for five days (8 hours/day) and shall staff the system for the entire duration of the test.
- After the successful completion of the first Field Performance Test phase, Subcontractor shall operate the treatment system for 8 hours/day for 5 days by pumping groundwater from the extraction wells for treatment and direct discharging the treated water into the permitted discharge point. Daily sampling will be performed to assure that the treated water meets the appropriate NPDES

discharge limits/surface water criteria. Weekly monitoring/sampling shall also be performed to ensure that the system's air emissions are in accordance with the system's DNREC air permit. Subcontractor shall staff the system for the entire duration of the test.

- Finally, Subcontractor shall operate the treatment system for 24 hours/day for 10 days by pumping groundwater from the extraction well for treatment and direct discharging the treated water into the permitted discharge point. Daily sampling will be performed to assure the treated water meets the appropriate NPDES discharge limits/surface water criteria. Weekly monitoring/sampling shall also be performed to ensure that the system's air emissions are in accordance with the system's DNREC air permit.

The test flow rate for all three phases shall be the anticipated recovery well flow rate of 158 gpm. The effluent shall meet the effluent limits listed in Table 1.

During the Field Performance Test, the downtime for equipment adjustments shall not exceed 1 hour per day and operator interface is allowed only on 1 eight hour shift per day during the continuous (24 hr/day) portion of the test. If at any time during the test, equipment downtime exceeds 1 hour per day or operator interface is required on more than 1 shift (during the continuous portion of the test), the test shall be terminated and restarted to repeat that phase of the test in its entirety. The one hour of downtime is included to provide for operational adjustments to compensate for any changes in raw water quality or flow rate.

It is not intended that the 1 hour time period be included as a normal plant operational procedure. If the groundwater collection system is unable to provide the test flow rate, the system shall be placed in partial recirculation. In addition to meeting the mechanical operational requirements stated in this paragraph, the discharge limits listed in subsection 1-2 of this specification must be met at all times on each of the last five days of the Field Performance Test for the test to be considered successful and complete. The cost of field performance testing regardless of the duration of testing shall be included in the Subcontractor's bid price. The successful completion of the field performance test (as outlined herein) is required to gain acceptance of the treatment system. Contractor damages resulting from failure of the Subcontractor to successfully complete the Field Performance Test within the Subcontract specified time of 150 days from Subcontract execution are specified in the Subcontract Agreement. The Subcontractor shall give a minimum of 2 weeks notice prior to conducting the field performance test.

3-2.02.02 Analytical Testing. The following minimum number of water samples shall be collected and analyzed by Subcontractor for the applicable parameters indicated in Table 3 (according to discharge point) during the Field Performance Test. Additional analyses required are also indicated.

**Table 3 Field Performance Test Sampling Requirements**

<b>Sample Location</b>	<b>Number of Samples Required</b>	<b>Additional Analyses Required</b>
Influent Stream from Recovery Well Pumps	One sample every 24 hours	TCL Organics; TAL Metals
Air Stripper Liquid Effluent	One sample every 24 hours	TCL Organics
Outlet Stream From Effluent Holding Tank, T-1200	One sample every 24 hours:	TCL Organics; TAL Metals

In addition, the Subcontractor shall confirm the effectiveness of the system's vapor phase carbon units on a weekly basis by collecting and analyzing (for TCL organics) once during each five day period one air sample from before the first vapor phase carbon unit and one air sample from after the second vapor phase carbon unit. The results from these analyses shall be compared to ensure that a VOC removal rate being achieved by the vapor phase carbon unit is in accordance with the system's DNREC air permit equivalency.

The cost of analyses (by the Subcontractor) for the testing shall be provided for in the Subcontractor's unit price pricing proposal. Any analyses required in excess of these 25 days of testing to prove the system shall be provided at no additional cost to the Contractor or Owner.

3-2.02.03. Sample Handling. All samples taken during the field performance test shall be collected by the Subcontractor and witnessed by the Contractor. All samples shall be sealed in the presence of the Contractor and the testing laboratories shall verify and note that the seal was intact.

Each sample shall be labeled with the following information:

- Date of Run
- Time Period
- Test Conditions (i.e., Flow Rate, Metering Pump Settings, Control Settings, etc.)
- Sample Location

- Sampler
- Witness
- Sample Designation
- Analysis to be Performed

3-2.02.04 Methods and Reporting. All samples shall be collected by Subcontractor using USEPA approved methods. All analyses of liquids shall be in accordance with 40 CFR Part 136 methods. All analyses shall be performed by an appropriately licensed analytical laboratory that has been previously approved by Contractor. Analytical results as part of startup and field performance testing will be reported within 24-hours.

Within 14 calendar days of the completion of the Field Performance Test, Subcontractor shall submit a Field Performance Test Report, including all test data, operating records generated by the PLC or prepared by the operator, showing that the performance met the specifications at the flow rate and inlet concentration tested.

3-3. LONG-TERM OPERATION AND MAINTENANCE. Following final completion of the Field Performance Test and as directed by the Contractor, the Subcontractor shall assume long-term operation and maintenance of the system, presently estimated at a maximum duration of 24 months. Depending on the outcome of discussions with EPA and DNREC this initial timeframe for Subcontractor O&M might be reduced to 12 months. Subcontractor shall provide all necessary manpower, equipment, materials, chemicals, analytical services, and supplies needed for O&M. Subcontractor shall be responsible for chemical analysis to determine if the system is operating as designed and to meet effluent limits.

The following is a partial listing of normal routine minimum requirements that the Subcontractor must perform:

- Weekly site visits (at least one per week) to ensure the proper functioning of the treatment system.
- Assisting Contractor with the collection of samples (at a frequency specified in the system's NPDES permit) from the system's influent and effluent shall be collected for analysis. Analytical parameters will be in accordance with the requirements of the discharge permit. At a minimum, analyzed parameters will include pH, TCL volatile organics. Analytical methods to be used are as specified in the system's NPDES

permit.

- Collection of samples (on a weekly basis) from between the primary and secondary liquid phase carbon units and analyzed for TCL volatile organics using the analytical methods specified in the system's NPDES permit. If it is determined that breakthrough of the first carbon unit is occurring, Subcontractor shall schedule replacement of the liquid phase carbon units at such a time so as to maximize usage of the carbon while preventing any system shut down because of noncompliance with the required NPDES permit discharge criteria.
- Assisting the Contractor in the monitoring the system's off-gas for VOCs (using a photoionization detector (PID)) at points immediately before the first vapor phase carbon unit and immediately after the second vapor phase carbon unit. The results from these locations shall be compared to determine if the system is achieving VOC removal from the air stripper off-gas sufficient to meet the requirements of the system's DNREC air permit. In addition, the off-gas shall be monitored for VOCs at a point between the first and second vapor phase carbon units to determine if breakthrough is occurring. If it is determined that the vapor phase carbon is not achieving total VOC removal sufficient to meet the system's DNREC air permit, Subcontractor shall assist Contractor in collection of off-gas samples for analysis of VOCs and SVOCs, and Subcontractor shall shut down the system and immediately replace the carbon as specified in the air permit. If it is determined (from monitoring conducted between the two vapor phase carbon units) that breakthrough of the first carbon unit is occurring, Subcontractor shall schedule replacement of the vapor phase carbon units at such a time so as to maximize usage of the carbon while preventing any system shut down because of noncompliance with the required treatment levels.
- Necessary tasks for the beginning of the month visit include recording all flow meter readings, pressure gauge readings, pump cycle counter readings, calculation of monthly flows from the recovery well, and comparison of calculated flow from flow electronically transmitted from meters to the PLC. Where discrepancies between flows exceed 10%, flow meters shall be inspected, repaired, or replaced.
- Additional monthly tasks include, but are not limited to, adjusting valve settings throughout the recovery and treatment system as necessary to optimize operations, make changes to recovery well pump setting depths at the direction of the Contractor,

to perform monitoring well water level measurements and dissolved oxygen readings (bi-monthly), routine, non-routine, and preventative maintenance on electro-mechanical devices in accordance with manufacturer's recommendations, and to repair or replace worn or wearing or defective parts, etc.

- Fill out and complete a site visit report for each site visit documenting work activities performed, system adjustments completed, meter and gauge readings, personnel on-site, observed potential problems, etc.
- Inspect each recovery well for signs of leaks or other abnormal operation. Should a leak be observed, make necessary repairs or replacement of piping or parts causing the leak or damaged by the leak, to include site restoration if necessary.
- Bag filter media shall be replaced on an as-needed basis with a frequency so as to ensure that the treatment system flow rate is not decreased by more than 20% as a result of clogged/plugged media.

The Contractor shall prepare and submit a monthly discharge monitoring report (DMR) which shall be submitted to the DNREC in accordance with the requirements listed in the NPDES permit, with copies provided to the Subcontractor. In addition, the Subcontractor shall prepare and submit a Monthly Progress Report by the 12<sup>th</sup> of the following month to the Contractor. The report shall include:

- Copies of laboratory reports for all samples collected and analyzed.
- Monthly and cumulative total gallons of effluent and/or backwash water discharged to the POTW and to the NPDES permitted discharge point.
- Monthly and cumulative total gallons of water produced from the system's recovery wells.
- Bi-monthly and historical monitoring well water level and dissolved oxygen data.
- Copies of site visit reports for the month.
- Subcontractor's report of system run time, including documentation to support the value claimed including documentation to support exempt down time.
- Other pertinent information, such as operational problems and changes.

The Contractor shall review the report and potentially provide comments which Subcontractor will address and provide written response.

Subcontractor will also be responsible for dewatering, sampling, analysis, and offsite disposal (regeneration) of all spent carbon.

The Subcontractor is required to maintain a minimum system run time of 95%. Downtime due to utility power outages will not count against the subcontractor, unless the system does not auto re-start and the subcontractor did not perform a site visit to address the problem within 16 hours of power restoration.

It is anticipated that system run time will be determined based on the following:

- A run time counter indicating "Power On" to the MCC.
- Flow meter readings from recovery wells and the system effluent pump.

Unless otherwise specified by the Contractor, the system will only be considered to be operating when it is meeting the prescribed discharge limits set herein and processing extracted groundwater at a rate at least equal to the maximum sustainable extraction rate achievable by recovery wells RW-100 through RW-107 but not greater than 158 gpm. This maximum flow rate might be adjusted upward if it is subsequently determined by the Contractor that higher withdrawal rates are required to maintain plume containment.

3-3.01. Permit Exceedances During O&M Period. In the event of a NPDES discharge permit (or air permit equivalency) exceedance, Subcontractor shall comply with all reporting requirements specified in the NPDES permit (or air permit) for the system in question. In the case of a NPDES permit exceedance, Subcontractor shall, within 3 calendar days of becoming aware of the exceedance, at no cost to the Contractor or EPA, assist Contractor in the re-sampling of system influent, effluent, and intermediate locations in treatment process in an effort to determine the likely cause of the exceedance and make any needed process modifications to restore the system to compliance. Laboratory turn-around time for these samples will be no greater than 72 hours. In the case of an air permit equivalency exceedance, Subcontractor shall immediately shut down the system and replace the carbon in the vapor phase carbon units.

During this investigation/corrective action period, discharge will be directed to the NPDES permitted discharge point provided the discharge is in compliance with that permit. Otherwise, the system will either be shut down, operated in a closed loop, or will discharge



to a temporary tank to be provided by the Subcontractor at no cost to the Contractor or EPA. Time during which the system is operated in a closed loop, discharges to a temporary tank, or is shut down will be deducted from the total hours of run time during the month.

Within 5 calendar days of becoming aware of an exceedance of either the NPDES permit or the air permit, Subcontractor shall telephone Contractor to discuss the matter and fax a report providing the results of any analytical samples, description of the suspected cause of the exceedance, and recommended and/or completed actions which the Subcontractor has, or intends to take, to correct the problem along with an estimated schedule to complete. In the event the results of the re-sampled effluent meet the required permit criteria, no further action is required of the Subcontractor other than providing the report described above. In the event the results of the re-sampled effluent failed to meet the required permit criteria, Subcontractor shall perform any and all actions necessary, at no cost to the Contractor or EPA, to correct the problem. The problem will be considered corrected when effluent/emissions results are in compliance with the required permit criteria for two consecutive days.

In the unlikely event that three (3) NPDES discharge permit or air permit exceedances occur during any 6-month period, in addition to the investigative sampling and reporting described above, Subcontractor will submit, for approval of the Contractor, a System Modification Plan (SMP). The SMP will describe proposed system modifications that may include, but not necessarily be limited to, the following:

- The addition of additional carbon units.
- The addition or substitution of other new treatment technology.

Subcontractor shall prepare the SMP, implement the approved modifications, and demonstrate discharge permit compliance at no cost to the Contractor or EPA.

END OF SECTION

## **EQUIPMENT DATA SHEETS**

## INFLUENT HOLDING TANK

Designation	T-500
Unit Type	Vertical Tank
Number	1
Nominal capacity (gallons)	5,200
Operating capacity (gallons)	5,000
Outside diameter (feet)	10
Height (feet)	9
Tank material	Epoxy coated steel
Lining	Epoxy
Manway	24 inches, top
Inlets/Outlets	4-inch flanged process lines and as indicated on detail drawings
External Sight Glass	Per manufacturer's recommendations

NOTE: All size and volume values are approximate.

## EFFLUENT HOLDING TANK

Designation	T-1200
Unit Type	Temporary Vertical Tank
Number	1
Nominal capacity (gallons)	5,200
Operating capacity (gallons)	5,000
Outside Diameter (feet)	10
Height (feet)	9
Material	Fiberglass-reinforced plastic
Manway	24 inches, top
Inlets/Outlets	See drawing details
External Sight Glass	Per manufacturer's recommendations

NOTE: All size and volume values are approximate.

## SECTION 11710

### SYSTEM MONITORING AND CLEANUP VERIFICATION

#### PART 1 - GENERAL

##### 1.01. SCOPE OF WORK

- A. Subcontractor shall be responsible for monitoring and meeting the applicable discharge criteria as specified in Section 11430.
- B. Subcontractor shall prepare a Construction Quality Control Plan (CQCP) in accordance with the Contractor's Quality Assurance Project Plan (QAPP). The CQCP will address sample collection procedures and analytical methods. The CQCP plan shall be submitted to the Contractor for approval prior to commencement of sampling activities.

##### 1.02. RELATED QUALITY CONTROL WORK NOT INCLUDED IN THIS SECTION

- A. Earthwork is included in Section 02200.
- B. Quality Control (QC) sampling for chemical testing is included in Section 1605.
- C. The groundwater treatment system is included in Section 11430.
- D. Discharge criteria for treated water from the treatment system are specified in Section 11430.

##### 1.03. SUBMITTALS

- A. Subcontractor shall submit to the Contractor in accordance with Section 01300 the following for approval:
  - 1. Schedule showing times that system performance monitoring activities will be conducted and a summary of work to be done during each instance.
  - 2. CQCP Plan as specified in 1.01B of this Section.
  - 3. Qualifications and experience of the analytical laboratory proposed to perform analyses.

##### 1.04. QUALIFICATIONS. All sample collection, preservation, and chain-of-custody

procedures used to conduct the work specified herein shall be conducted in accordance with Region III standard operating procedures. All laboratory analyses performed shall be in accordance with standard EPA methods. Quality assurance procedures shall be conducted as specified in Region III guidance.

## PART 2 – PRODUCTS

2-1. MATERIALS. Subcontractor, at no additional cost to Contractor, will furnish all miscellaneous tools, equipment, and materials required to perform the work of this section.

## PART 3 - EXECUTION

### 3-1. SYSTEM PERFORMANCE MONITORING FOR GROUNDWATER TREATMENT SYSTEM.

- A. The Subcontractor shall be responsible for system testing and startup procedures. Upon completion of construction of all components, a 25 day long system startup and testing period is anticipated. It will consist of the following:
- 5 days (8 hours/day) of closed loop operation of the systems that is staffed for the entire duration. Potable water will be run through the system in a closed loop to work out any major system flaws.
  - Next, groundwater would be pumped from the extraction well and sent through the treatment system. The treated groundwater will be discharged into temporary, on-site storage tanks (Baker/Frac tanks) for daily analytical testing. Treated groundwater will be discharged into the discharge points once testing results indicate the water meets the NPDES surface water criteria. It is anticipated that the system will be operated in this fashion for 5 days (8 hours/day) and require staffing for the entire duration.
  - Upon successful completion of the above step, the treatment system will be operated for 8 hours/day for 5 days by pumping groundwater from the extraction well for treatment, and direct discharge into the storm sewer. Daily sampling will be performed to assure that the treated water meets the NPDES surface water criteria.
  - Then the treatment system will be operated for 24 hours/day for 10 days by pumping groundwater from the extraction well for treatment, and direct discharge into the storm sewer. Daily sampling will be

performed to assure the treated water meets the NPDES surface water criteria.

- Finally, since air emissions from the subject system are anticipated to be negligible, this design assumes no additional controls will be required. To ensure that the treatment system meet the requirements of DNREC's air permit discharge limits on this system, the subcontractor will monitor volatile organic compound (VOC) emissions on a weekly basis at sample points immediately before the first vapor phase carbon unit and immediately after the second vapor phase carbon unit. Monitoring shall be performed using a properly maintained and calibrated photoionization detector that has been approved by the Contractor.
- B. The Subcontractor shall be responsible for monitoring and meeting treatment system performance criteria specified in Section 11430. Contractor shall be responsible for verification of system performance by collecting samples specified in Parts 3-2.02.02 and 3-3 of Section 11430. One grab sample shall be collected each from the influent holding tank and the effluent discharge line sample port. The required level of detection shall be no greater than the lesser of the NPDES permit specified discharge limit or 1 : g/l for each constituent. Maximum laboratory turnaround time for analytical results shall be seven days during sampling.
- C. If the influent concentrations to the groundwater treatment system from the influent holding tank exceed those listed in Table 1 of Section 11430, and the required NPDES discharge limits, the 95% removal requirement for VOCs in the system's air emissions, and/or the backwash discharge limits cannot be achieved, the Owner may direct the Contractor to make such modifications to the treatment system to meet the effluent criteria. Any costs for such modifications shall be borne by the Owner, providing the Subcontractor is operating and maintaining the equipment properly.
- D. If the influent concentrations to the treatment system are below those listed in Table 1 of Section 11430 and the NPDES discharge limits, the 95% removal requirement for VOCs in the system's air emissions, and/or the backwash discharge limits cannot be achieved, Subcontractor shall make such modifications to the treatment system as necessary to meet the required criteria.

Any costs for such modifications including additional analytical costs shall be borne by Subcontractor. During the time period in which modifications are being made, if possible, Subcontractor shall continue to operate the system but direct the discharge to the lift station onsite provided the effluent is in compliance with the POTW's discharge requirements.

- E. Duplicate copies of all water analyses results shall be submitted to the Contractor.

### 3.02. GROUNDWATER TREATMENT SYSTEM STATUS REPORTING

- A. Subcontractor shall prepare and submit to the Contractor monthly status reports (due on the 12<sup>th</sup> of the following month) describing operation of the groundwater treatment and ancillary equipment. Each status report shall at a minimum identify the following, as applicable.

1. Totalized system influent and effluent to the Red Lion Creek discharge point in gallons.
2. Instantaneous system flow rates on the days of site visits in gpm.
3. Quantity of any sludge accumulations.
4. All system water pressure gauge readings in psi.
5. Well average instantaneous flow rates in gpm.
6. Process pumping discharge pressure in psig and/or blower discharge air pressure in inches water.
7. Operational status of all major system components.
8. Any system downtime in hours and reason for downtime.
9. Any maintenance activities performed on the system.
10. All analytical laboratory results from system monitoring as specified in Part 3.01 of this Section.
11. Security incidents.
12. Health and safety incidents.

- B. Item numbers 1 through 7 in Part 3.02A above shall be reported based on observed daily readings at approximately the same time every day.

- C. Subcontractor shall submit these reports on a weekly basis during the system prove-out, system start up, and Field Performance Test phases.



END OF SECTION

## Section 13120

### PRE-ENGINEERED STRUCTURE

#### PART 1- GENERAL

1-1. SCOPE. This section specifies the requirements of the steel framed, pre-engineered structure.

1-2. GENERAL DESCRIPTION OF WORK. Provide all labor, materials, erection and equipment to complete a pre-engineered metal building as indicated in the Contract Documents.

Materials included primary and secondary framing members, bracing, metal panels for roofing and siding, flashing, fasteners, sealant, doors, louvers, accessories and all other miscellaneous component parts required for a complete building including column anchor bolts, gutters and down spouts. Insulation and other specified items shall also be included.

The Subcontractor is responsible for developing an approved foundation plan and is required to submit deviations to the plans to the Contractor for approval if significant differences from the original device should occur.

#### 1-3. REFERENCES AND CODES.

- A. AISC - Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.
- B. AISI - Specification for the Design of Light Gauge Cold-Formed Steel Structural Members.
- C. SSPC - Steel Structures Painting Council Specifications.
- D. AWS - American Welding Society Specifications.
- E. ASTM - American Society for Testing and Materials Specifications
- F. MBMA - Metal Building Manufacturers Association Specifications
- G. BHMA - Builders Hardware Manufacturers Association Specifications
- H. ANSI – American National Standards Institute Specifications
- I. ASCE – American Society of Civil Engineers Specifications

1-4. DESIGN CRITERIA AND RESPONSIBILITY.

A. Roofing, Siding

Roofing, siding, cold formed purlins and first shall conform to the provisions of the current Specifications for the Design of Light Gauge Cold-Formed Steel Structural Members of the American Institute of Steel and Iron Construction (AISI).

B. Design Loads

1. Building Loads

- a. Roof Snow Load: 30 psf.
- b. Plus 3 psf superimposed roof collateral load
- c. Wind Loads: The greater of: Delaware Building Code or ASCE 7-95 Minimum Design Loads for Building and Other Structures
- d. Seismic Loads: Delaware Seismic Code
- e. Live Loads: Delaware Building Code

C. Materials Requirements:

- 1. Plates and rolled shapes: minimum yield stress of 42,000 psi (ASTM A572, A570 or A36 as applicable);
- 2. Cold-formed members, purlins, sheeting and endwall columns/rafters: yield stress of 50,000 psi (ASTM A570);
- 3. Bolts: ASTM A325 (primary) or A307 (secondary);
- 4. All welds shall be in accordance with AWS "Structural Welding Code" by certified welders.

D. Drift Provisions;

Lateral deflections, or drift at the roof level of a structure in relation to the floor or slab on grade, caused by deflection of horizontal force resisting elements shall conform to MBMA-O1. Masonry walls shall be isolated from the steel framing.

1-5. SUBMITTALS.

A. Design Calculations and Drawings

Submit complete design computations and Construction Drawings covering foundations and all primary framing members, connections, bracing, siding, girts, roofing, purlins and sag rods prior to the preparation of shop details and fabrication.

B. Erection Drawings and Certification

Furnish complete shop drawings and erection drawings showing anchor bolt setting, sidewall, endwall, and roof framing, transverse cross-sections, covering flashing details and accessory installation details to clearly indicate the proper assembly of all building parts. The Subcontractor shall also furnish a certificate, signed by a Professional Contractor or Architect licensed in the State of Delaware familiar with the design of the building, that the building design meets the requirements of the Specifications and is in accordance with accepted Contracting practices. Detail sheets shall be numbered and cross-referenced for convenient location on erection drawings.

C. Furnish shop drawings of pre-formed metal roofing system and pre-formed metal siding system.

D. Anchor bolt setting plans shall include column reaction for use in verification of the adequacy of the foundation plans.

E. Foundation Plans

Submit foundation plan for treatment facility certified by a Delaware Licensed Professional Contractor

F. Warranty:

1. Manufacturer shall furnish a five (5) year limited warranty against failures caused by faulty or substandard material. Warranty shall also certify the design criteria used for the structural design of the building.
2. Warranty shall also include a one (1) year workmanship guarantee against failures caused by faulty erection.
3. All panels, which are color coated with paint shall be warranted, within limits set by the warranty, for a period of 10 years against chalk, fade, crack, check, blister or peel.

## PART 2 - PRODUCTS

- 2-1. MANUFACTURERS. Subject to compliance with the requirements specified in this Section, provide a product as manufactured by Butler Manufacturing Co., Grandview,

MO; Varco-Pruden Buildings, Memphis, TN; or American Buildings Co., Eufaula, AL; or Contractor approved equal.

2-2. INSULATED ROOFING SYSTEMS.

Pre-Formed Metal Roofing System

Standing seam metal roofing system with concealed fasteners and allowance for thermal expansion and contraction. Minimum gauge of outer and inner panels - 24 gauge; insulation providing a maximum U value of 0.05 through the panel, with manufacturer's 15 year life minimum factory coating system over commercial quality, galvanized steel panels - color as selected by Contractor.

Pre-formed standing seam metal roofing system shall be aluminized steel and shall be similar and equal to one of the following:

1. "CMR-24" by Butler Manufacturing Company.
2. "SSR Roof System" by Varco-Pruden Buildings.
3. "American Standing Seam 360 Roof System" by American Buildings Company.

2-3. INSULATED EXTERIOR WALLS. Minimum gauge of outer and inner panels - 24 gauge; fiberglass batt insulation providing a maximum U value of 0.14 through the panels with manufacturer's 15 year life minimum factory coating system over commercial quality, galvanized steel panels - color as selected by the Contractor.

Insulated wall system shall be similar and equal to one of the following:

1. "Thermawall" by Butler Manufacturing Co.
2. "VP, 202" by Varco-Pruden Buildings.
3. "Shadow Panel" with 3-in. rigid insulation by American Buildings Co.

2-4. EAVE TRIM, CORNER TRIM AND FLASHING. All trim shall be 22 gauge of same materials that are used for the roof or siding, as applicable. Finish and color shall be as selected by the Contractor.

2-5. PERSONNEL DOOR AND FRAME. Insulated Door Leaves shall be 1 3/4" thick flush construction of a nominal 20 gauge galvanized steel. Leaves shall be manufactured in accordance with ANSI/SDI-100, Grade 1, Model 1, (STC rating 22 and U value .07), solid panel type. Door frames shall be 4 3/4" deep, of nominal 16 gauge, galvanized steel.

Frames shall have hinge reinforcement of a nominal 7 gauge and a lock reinforcement of a

nominal 16 gauge. All leaves and frames shall be factory painted.

2-6. OVERHEAD DOORS.

- A. Overhead Coiling Doors shall be as manufactured by Raynor Manufacturing Company, Model N40 with IF slats and RGJH operator or approved equal.
- B. Curtain shall consist of interlocking flat vertical exterior surfaces roll-formed from not less than 24-gauge finish factory standard. Curtain slats shall incorporate a two-coat baked-on prime paint applied prior to roll-forming to assure complete and even coverage.
- C. Interlocking slats shall have 3/4-inch thick, expanded polystyrene core placed within the full length of each slat.

2-7 ADJUSTABLE WALL LOUVERS. Adjustable louvers shall be of self framing design. The louver frame shall be of nominal 14 gauge formed aluminum and the louver blades shall be nominal 12 gauge extruded aluminum. All louvers shall be complete with an exterior mounted aluminum mesh insect screen.

2-8 HIGH STRENGTH BOLTS, NUTS AND WASHERS, ANCHOR BOLTS. All high strength bolts, nuts, washers and anchor bolts shall conform to ASTM A 325 or ASTM A 490 standards.

2-9 PAINT. Provide exterior and interior exposed surfaces of metal roof and wall panels, gutters, downspouts and metal accessories with a thermal-cured factory finish. Color shall be selected from manufacturer's selected colors. All primary framing members, connections, bracing, girts, roofing, purlins and sag rods are to be factory primed. Painting shall be covered under manufacturer's warranty for a period of 10 years.

PART 3 - EXECUTION

3-1. FABRICATION AND ERECTION. Building is to be erected as per manufacturer's recommendations. See Section 1-1.

END OF SECTION

## Section 15060 - MISCELLANEOUS PIPING

### PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing and installation of miscellaneous piping and piping accessories (except as otherwise indicated) for all services. The following items are covered in other sections:

- Pipe supports and anchors
- Pipe trenching, bedding, and backfill
- Polyvinyl chloride pressure pipe
- Polyvinyl chloride sewer pipe
- High Density Polyethylene Pipe

Miscellaneous piping shall be furnished and installed complete with all fittings, jointing materials, hangers, supports, anchors, and other necessary appurtenances. All piping shall be affixed with labels indicating flow direction and pipe content.

1-2. SUBMITTALS. Complete specifications, data, and catalog cuts or drawings covering the following items furnished under this section shall be submitted in accordance with Specification Section 01300 - Submittals.

### 1-3. SERVICE AND TYPE REQUIREMENTS

Except as otherwise specified, pipe and tubing shall conform to the general requirements in this section. Pipe materials for service conditions not listed shall be as specified in other sections, as indicated on the drawings, or, in the absence of any definite requirement, as determined by the Contractor.

Where optional pipe materials or fittings are listed for a particular service, the Subcontractor may select the materials and fittings from the options offered.

For all services where ASTM A53 steel pipe is required, ASTM A106 steel pipe of equivalent wall thickness will be acceptable.

## PART 2 - PRODUCTS

### 2-1. MATERIALS.

#### Steel Pipe

The specific type of pipe material and wall thickness for each service listed shall conform to the requirements of the applicable Piping Schedule paragraph.

ASTM A53, seamless (Type S), or electric resistance welded, (Type E), Grade A or B.

ASTM A106, Grade A or B.

#### Nipples

ASTM A733, seamless, extra strong (Schedule 80); "close" nipples will be permitted only by special authorization in each case.

#### Fittings

##### Cast Iron

##### Threaded

ANSI/ASME B16.4, Class 125.

##### Flanged

ANSI/ASME B16.1, Class 125.

##### Malleable Iron

ANSI/ASME B16.3, Class 150, or Fed Spec WW-P-521, Type II (galvanized) for galvanized pipe or Type I (black) for non-galvanized pipe.

##### Forged Steel

ANSI B16.11; Bonney, Crane, Ladish, or Vogt.

##### Threaded

Class 2000 or Class 3000.

##### Buttwelding

ANSI/ASME B16.9; standard weight for use with standard weight pipe and extra strong for use with extra strong pipe.

#### Unions



Malleable Iron	Fed Spec WW-U-531, Class 2; Type B (galvanized) for galvanized pipe or Type A (black) for ungalvanized pipe.
Flanges	
For Standard Weight Pipe faced when connected to flat faced flanges; otherwise, raised face.	ANSI/ASME B16.5, Class 150, flat
Flange Bolts and Nuts	ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut.
Flange Gaskets	
For Water Service	ASTM D1330, Grade I, red rubber, ring type, 1/8 inch thick.
For Other Services	
Flat Faced Flanges	Non-asbestos filler with neoprene or nitrile binder; dimensions to suit flange contact face; 1/16 inch minimum thickness for plain finished surfaces, 3/32 inch minimum thickness for serrated surfaces.
Raised Face	Continuous stainless steel ribbon.
Flanges	wound into a spiral with non- asbestos filler between adjacent coils with a carbon steel gauge ring. Compressed gasket thickness shall be 0.095 inch " 0.005 inch.
Mechanical Couplings	Dresser "Style 38" or Smith-Blair "Type 411 Flexible Coupling"; without pipe stop.
Expansion Joints	Senior Flexonics, Inc. "Model H Expansion Compensators" for 3 inch or smaller; Senior Flexonics, Inc. "Low Pressure High Corr Expansion Joints" 150 psig with flanged ends and stainless steel bellows for 4 inch or larger.

## Copper Tubing

### Water Tubing

Hard Drawn

ASTM B88, Type L.

Soft Annealed

ASTM B88, Type K; cadmium plated where used for chlorine service .

### Instrument Tubing

Material

ASTM B280, soft annealed.

Dimensions

ASTM B280.

### Fittings

Flared

ANSI/ASME B16.26.

Solder-Joint

ANSI B16.18 or ANSI/ASME B16.22.

Compression

Brass; Crawford "Swagelok" or Parker Hannifin "CPI".

### Insulating

Threaded

Dielectric steel pipe nipple, ASTM A53, Schedule 40, poly- propylene lined, zinc plated; Perfection Corp. "Clearflow Fittings".

Flanged

Epco "Dielectric Flange Unions" or Central Plastics "Insulating Flange Unions".

Solder

Solid wire, ASTM B32, Alloy Grade Sb5, (95-5).

Soldering Flux

Paste type, Fed Spec O-F-506, Type I, Form A.

Brazing Filler Metal

AWS A5.8, BCuP-5; Engelhard "Silvaloy 15", Goldsmith "GB-15", or Handy & Harman "Sil-Fos".

Brazing Flux

Paste type, Fed Spec O-F-499, Type B.

Flanges	ANSI B16.24, Class 150, cast bronze, brazed joint.
Flange Bolts and Nuts	ASTM A307, Grade B, length such that, after installation, the bolts will project 1/8 to 3/8 inch [3 to 9 mm] beyond outer face of the nut.
Flange Gaskets	ASTM D1330, Grade I, red rubber, ring type, 1/8 inch thick.
Expansion Joints	Tempflex "Model HB Expansion Compensators", with copper tube ends.
PVC Pipe, Schedule 40	
Pipe	ASTM D1785, Cell Classification 12454-B, bearing NSF seal.
Fittings	ASTM D2466, Cell Classification 12454-B, bearing NSF seal.
Solvent Cement	ASTM D2564.
Primer	ASTM F656.
PVC Pipe, Schedule 80	
Pipe	ASTM D1785, Cell Classification 12454-B, bearing NSF seal.
Fittings	ASTM D2464 or D2467, Cell Classification 12454-B, bearing NSF seal.
Flanges	Diameter and drilling shall conform to ANSI/ASME B16.5, Class 150.
Flange Bolts and Nuts	ASTM A307, Grade B, galvanized, length such that, after installation, the bolts will project 1/8 to 3/8 inch [3 to 9 mm] beyond outer face of the nut.
Flat Washers	ANSI B18.22.1, plain, galvanized.

Flange Gaskets Full face, 1/8 inch [3 mm] thick, chemical-resistant elastomeric material suitable for the specified service.

Solvent Cement ASTM D2564.

Primer ASTM F656.

Expansion Joints Edlon "Thermo-molded TFE" or Resistoflex "Style R6905" molded expansion joint.

### Stainless Steel Pipe, Schedule 10S

Pipe ASTM A312 or ASTM A778, Grade TP316L.

#### Fittings

Buttwelding ASTM A774, wrought stainless steel, Grade TP316L, with beveled ends and Schedule 10S wall thickness.

Flanged ASTM A774, wrought stainless steel, Grade TP316L, with angle face rings and stainless steel backing flanges.

Backing Flanges AISI Type 316 stainless steel plate, with ANSI/ASME B16.5, Class 150 diameter and drilling; with the following thicknesses:

Nominal Pipe Size	Flange Thickness
<u>inches</u>	<u>inches</u>
1/2-8	1/2
10-14	5/8
16-18	3/4
20-30	1
36	1-1/4

Flange Bolts and Nuts ASTM A307, galvanized, length such that, after installation, bolts will project 1/8 to 3/8 inch beyond outer face of nut.

Flange Gaskets	Flexitalic "Style CG", spiral wound, AISI Type 304 stainless steel, non-asbestos filler, 3/16 inch nominal thickness, with compression ring 1/8 inch thick to match required flange dimensions.
Stainless Steel Pipe, Schedule 40S	
Pipe	ASTM A312, Grade TP316L.
Fittings	
Buttwelding	ASTM A403, WP316L and ANSI/ASME B16.9, Schedule 40S.
Socket-Welding	ASTM A182, Grade F316L, and ANSI B16.11, Class 3000.
Threaded	AISI Type 316L Class 150, dimensions conforming to ANSI/ASME B16.3.
Flanges	ANSI/ASME B16.5, Class 150, flat faced, AISI Type 316L.
Flange Bolts	ASTM A193, AISI Type 304, ANSI B18.2.1, heavy hex head, length such that, after installation, the bolts will project 1/8 to 3/8 inch beyond outer face of the nut.
Nuts	ASTM A194, AISI Type 304, ANSI/ASME B18.2.2, heavy hex pattern.
Flange Gaskets	ASTM D1330, Grade I, red rubber, ring type, 1/8 inch thick.
Stainless Steel Tubing	
Tubing	ASTM A269, seamless, Grade TP316, annealed, max hardness Rockwell B80; with the following min wall thicknesses:

Tube OD	Wall Thickness
---------	----------------

<u>inches</u>	<u>inch</u>
1/4-3/8	0.065
1/2-7/8	0.083
1-2	0.109

Fittings

Compression type, AISI Type 316 stainless steel; Crawford "Swagelok", or Parker Hannifin "CPI" or "Ferulok".

#### PVDF DWV Pipe with Mechanical Joints

Pipe

Schedule 40, UL 94-VO, non-combustible. Orion or equal.

Fittings

Schedule 40, drainage pattern. Fittings and pipe shall be provided by the same manufacturer.

Joints

Manufacturers' standard.

#### Pipe Insulation

Hot Piping

ASTM C547, Class 1 (to 450°F), 1 inch thick, glass fiber, with flame-retardant vapor barrier jacket.

Cold Piping

Fed Spec HH-I-573, tubular, closed cell elastomeric, at least 3/4 inch thick.

#### Watertight/Dusttight

O-Z Electrical Manufacturing "Thruwall" and Pipe Sleeves "Floor Seals", or Thunderline "Link-Seals"; with modular rubber sealing elements, nonmetallic pressure plates, and galvanized bolts.

#### Anti-Seize Thread Lubricant

Jet-Lube "Nikal", John Crane "Thred Gard Nickel", Never-Seez "Pure Nickel Special", or Permatex "Nickel Anti-Seize".

#### Teflon Thread Sealer

Paste type; Hercules "Real-tuff", John Crane "JC-30", or Permatex "Thread Sealant with Teflon".

Teflon Thread Tape	Hercules "Tape Dope" or John Crane "Thred-Tape".
Pipe Sleeve Sealant	Polysulfide or urethane, as specified in the caulking section.
Protective Coatings	
Plastic-Coated Pipe	Chevron Chemical Co. "Plexco Plexguard Coating" or Encoat/Lukens "Encoat Extruded Coating". The products of other manufacturers will not be acceptable.
Tape Wrap	ANSI/AWWA C209, except single ply tape thickness shall not be less than 30 mils; Protecto Wrap "200" or Tapecoat "CT".
Primer	As recommended by the manufacturer.
Coal Tar Coating	Medium consistency; Carboline "Kop-Coat Bitumastic Super Service Black" or Tnemec "46-465 H.B. Tnemecol".

### PART 3 - EXECUTION

3-1. DELIVERY, STORAGE, AND HANDLING. Coated black steel pipe and fittings shall be handled and stored in a manner which will ensure installation in sound, undamaged condition. Handling methods and equipment used shall prevent damage to the protective coating and shall include the use of end hooks, padded calipers, and nylon or similar fabric slings with spreader bars. Bare cables, chains, or metal bars shall not be used. All piping shall be stored off the ground on skids. Whenever the storage period on the jobsite exceeds 30 days, plastic and plastic-coated pipe shall be covered or otherwise protected from exposure to sunlight.

3-2. Pipe Joints. Pipe joints shall be carefully and neatly made in accordance with the requirements which follow.

3-2.01 Threaded. Pipe threads shall conform to ANSI/ASME B1.20.1, NPT, and shall be fully and cleanly cut with sharp dies. Not more than three threads at each pipe connection

shall remain exposed after installation. Ends of pipe shall be reamed after threading and before assembly to remove all burrs.

Threaded joints in plastic piping shall be made up with teflon thread tape applied to all male threads. Threaded joints in stainless steel piping shall be made up with teflon thread tape applied to all male threads. At the option of the Subcontractor, threaded joints in other piping may be made up with teflon thread tape, thread sealer, or a suitable joint compound. Thread tape and joint compound or sealers shall not be used in threaded joints which are to be seal welded.

3-2.02 Compression. Ends of tubing shall be cut square and all burrs shall be removed. The tubing end shall be fully inserted into the compression fitting and the nut shall be tightened not less than 1-1/4 turns and not more than 1-1/2 turns past fingertight, or as recommended by the fitting manufacturer, to produce a leaktight, torque-free connection.

3-2.03 Flared. Ends of annealed copper tubing shall be cut square, and all burrs shall be removed prior to flaring. Ends shall be uniformly flared without scratches or grooves. Fittings shall be tightened as required to produce leaktight connections.

3-2.04 Soldered and Brazed. Where solder fittings are specified for lines smaller than 2 inches [50 mm], joints may be soldered or brazed at the option of the Subcontractor. Joints in 2 inch and larger copper tubing shall be brazed. Joints in copper chlorine tubing and refrigerant piping shall be brazed; solder will not be acceptable.

Surfaces to be joined shall be thoroughly cleaned with flint paper and coated with a thin film of flux. At each joint, tubing shall enter to the full depth of the fitting socket.

Care shall be taken to avoid overheating the metal or flux. Each joint shall be uniformly heated to the extent that filler metal will melt on contact. While the joint is still hot, surplus filler metal and flux shall be removed with a rag or brush.

3-2.05 Solvent Welded. All joint preparation, cutting, and jointing procedures shall comply with the pipe manufacturer's recommendations and ASTM D2855. Pipe ends shall be beveled or chamfered to the dimensions recommended by the manufacturer. Newly assembled joints shall be suitably blocked or restrained to prevent movement during the setting time recommended by the manufacturer. Pressure testing of solvent welded piping



systems shall not be performed until the applicable curing time, as set forth in Table X2.1 of ASTM D2855, has elapsed.

3-2.06 Epoxy and Adhesive Bonded. All joint preparation, cutting, and jointing procedures shall comply with the pipe manufacturer's recommendations. Adhesive shall be mixed and applied in accordance with the manufacturer's recommendations. After joining, either the pipe or the fitting shall be rotated approximately one-half turn to uniformly distribute adhesive. A slight fillet of adhesive at the bond line is desirable, but all excess adhesive shall be wiped off immediately. Newly assembled joints shall be suitably blocked or restrained to prevent movement during the curing period recommended by the manufacturer.

3-2.07 Heat Fusion Bonded Joints. All joint preparation, cutting, jointing equipment, and jointing procedures shall comply with the pipe manufacturer's recommendations. The heating time, temperature, pressure applied to the joint during bonding, and cooling time shall consistently produce leaktight joints as strong as the pipe being joined.

3-2.08 Flanged. Flange bolts shall be tightened sufficiently to slightly compress the gasket and effect a seal, but not so tight as to fracture or distort the flanges. A plain washer shall be installed under the head and nut of bolts connecting plastic pipe flanges. Anti-seize thread lubricant shall be applied to the threaded portion of all stainless steel bolts during assembly. Pipe sealants, thread compounds, or other coatings shall not be applied to flange gaskets unless recommended by the gasket manufacturer for the specified service and approved by the Contractor.

3-2.09 Welded. Welding shall conform to the specifications and recommendations contained in the "Code for Pressure Piping", ANSI B31.1.

3-2.10 Grooved Couplings. Grooves for grooved couplings shall be cut with a specially designed grooving tool. Grooves cut in steel pipe shall conform to flexible grooving dimensions, as set forth in AWWA C606, and shall be clean and sharp without burrs or check marks.

3-2.11 Push-on. Gasket installation and other jointing procedures shall be in accordance with the recommendations of the manufacturer. Each spigot end shall be suitably beveled to facilitate assembly. All joint surfaces shall be lubricated with a heavy vegetable soap solution immediately before the joint is completed. Lubricant shall be suitable for use in potable water, shall be stored in closed containers, and shall be kept clean.

3-2.12 Rubber-Gasketed. When rubber-gasketed joints are used for hub and spigot type cast iron soil pipe, spigot ends shall be plain, without beads. Cut ends of all pipe shall be cut square, beveled, and all burrs shall be removed. Spigot ends shall be coated with a lubricant recommended by the gasket manufacturer and fully seated in the gasket. Clamps for hubless cast iron soil pipe shall be installed in accordance with the manufacturer's recommendations.

3-2.13 Other Pipe Joints. Coupled joints in tempered glass pipe, plastic joints in vitrified clay pipe, and other proprietary type joints shall be made in accordance with the manufacturer's recommendations and to the satisfaction of the Contractor.

3-3. Pipe Sleeves. Piping passing through concrete or masonry shall be installed through sleeves installed before the concrete is placed or when masonry is laid. Pipe sleeves installed through floors with a special finish, such as ceramic or vinyl composition tile, shall be flush with the finished floor surface and shall be provided with nickel or chromium plated floor plates. Unless otherwise indicated on the drawings, in all other locations where pipes pass through floors, pipe sleeves shall project not less than 1 inch nor more than 2 inches above the floor surface, with the projections uniform within each area. In the case of insulated pipes, the insulation shall extend through pipe sleeves. Where the drawings indicate future installation of pipe, sleeves fitted with suitable plastic caps or plugs shall be provided.

Holes drilled with a suitable rotary drill will be considered instead of sleeves for piping which passes through interior walls and through floors with a special finish.

Unless otherwise indicated on the drawings, all pipes passing through walls or slabs which have one side in contact with earth or exposed to the weather shall be sealed watertight with special rubber-gasketed sleeve and joint assemblies, or with sleeves and modular rubber sealing elements.

Piping passing through room walls and floor shall be made dusttight and gastight with special rubber-gasketed sleeve and joint assemblies; with sleeves sealed with modular rubber sealing elements; or by caulking with oakum and polysulfide or urethane sealant.

3-4. Pipe Installation. Pipe shall be installed as specified, as indicated on the drawings, or, in the absence of detail piping arrangement, in a manner acceptable to the Contractor.

Water supply piping shall be provided with a shutoff valve and union at each fixture or unit of equipment, whether or not indicated on the drawings, to permit isolation and disconnection of each item without disturbing the remainder of the system.

A union shall be provided within 2 feet of each threaded-end valve unless there are other connections which will permit easy removal of the valve. Unions shall also be provided in piping adjacent to devices or equipment which may require removal in the future and where required by the drawings or the specifications.

Pipe shall be cut to measurements taken at the site, not from the drawings. All necessary provisions shall be made in laying out piping to allow for expansion and contraction. Piping shall not obstruct openings or passageways. Pipes shall be held free of contact with building construction to avoid transmission of noise resulting from expansion.

Water supply piping within structures shall be arranged, and facilities provided, for complete drainage. All piping serving metering equipment shall be uniformly graded so that air traps are eliminated and complete venting is provided.

Stuffing box leakage from water sealed pumps shall be piped to the nearest point of drainage collection.

Taps for pressure gauge connections on the suction and discharge of pumping units shall be provided with a nipple and a ball type shutoff valve.

Drilling and tapping of pipe walls for installation of pressure gauges or switches will not be permitted.

In all piping, insulating fittings shall be provided to prevent contact of dissimilar metals, including but not limited to, contact of copper, brass, or bronze pipe, tubing, fittings, valves, or appurtenances, or stainless steel pipe, tubing, fittings, valves, or appurtenances with iron or steel pipe, fittings, valves, or appurtenances. Insulating fittings shall also be provided to prevent contact of copper, brass, or bronze pipe, tubing, fittings, valves or appurtenances with stainless steel pipe, tubing, fittings, valves, or appurtenances.

Branch connections in horizontal runs of steam, air, and gas piping shall be made from the top of the pipe.

Buried PVC piping shall be "snaked" in the trench and shall be kept as cool as possible during installation. PVC pipe shall be kept shaded and shall be covered with backfill immediately after installation.

3-5. Chemical Piping. All chemical piping shall be installed so that lines are readily accessible for cleaning. Tees shall be provided at changes in direction in all chemical piping except chlorine piping, with extra openings plugged, to facilitate cleaning. Teflon thread tape or teflon thread sealer shall be applied to the threads of the plugs so that they can be easily removed. At each point where hose or reinforced plastic tubing is connected to rigid piping, a quick-disconnect coupling shall be provided.

3-6. Polyethylene Gas Piping. Polyethylene gas piping shall be installed in accordance with the manufacturer's recommendations. A continuous 12 AWG THHN insulated copper tracer wire shall be placed 6 inches above all portions of the buried pipe. Where the pipe extends above grade, a 2 foot length of wire shall be coiled and attached to the pipe.

3-7. Insulation. Pipe insulation shall be neatly installed by skilled workers. Piping shall be clean and dry and shall have been tested before insulation is applied.

End joints shall be tightly butted. Seams and joints shall be held by the manufacturer's standard adhesive. Jacket laps shall be neatly pasted in place. All joints shall be pointed with insulating cement.

Fittings, flanges, and valves shall be insulated with molded insulation or insulating cement of the same thickness as the pipe insulation. Hangers shall permit insulation to pass through and suitable saddles shall be provided so that the weight of the piping is not supported by the insulation.

3-8. Protective Coating. Black steel pipe in buried locations shall have exterior surfaces protected with a shop-applied plastic coating.

At the option of the Subcontractor, extra strong black steel pipe in buried locations shall have exterior surfaces protected either by shop-applied plastic coating or by shop or field applied tape wrap.

The exterior surfaces of all fittings, couplings, specials, and other portions of buried piping not protected with plastic coating shall be tape-wrapped in the field. All surfaces to be tape-

wrapped shall be thoroughly cleaned and primed in accordance with the tape manufacturer's recommendations immediately before wrapping. The tape shall be applied by two-ply (half-lap) wrapping or as required to provide a total installed tape thickness of at least 60 mils. Joints in plastic-coated pipe shall be cleaned, primed, and tape-wrapped after installation.

Joints in galvanized steel piping in underground locations shall be field painted with two coats of coal tar coating.

3-8.01 Inspection. All shop-applied plastic coatings and tape wrap on pipe or fittings shall be inspected for holidays and other defects after receipt of the pipe or fitting on the job and immediately before installation. All field-applied tape wrap on pipe, joints, fittings, and valves shall be inspected for holidays and other defects following completion of wrapping. Inspection of plastic coatings after installation of the pipe or fitting in the trench shall be made where, in the opinion of the Contractor, the coating may have been damaged during installation. Holidays and defects disclosed by inspection shall be repaired in accordance with the recommendations of the coating or tape wrap manufacturer, as applicable.

The inspection shall be made using an electrical holiday detector. The detector and inspection procedures shall conform to the requirements of Section 4.4 of ANSI/AWWA C209.

3-9. Pressure And Leakage Testing. All specified tests shall be made by and at the expense of the Subcontractor in the presence, and to the satisfaction, of the Contractor. Each piping system shall be tested for at least 1 hour with no loss of pressure. Piping shall be tested at the following pressures:

<u>Service</u>	<u>Test Pressure</u>	<u>Test Medium</u>
Water supply	1-1/2 times working pressure but not less than 120 psi	water
Other piping	1-1/2 times working pressure but not less than 50 psi	suitable fluid or gas; for distilled water piping, distilled water or filtered oil-free compressed air may be used

Compressed air or pressurized gas shall not be used for testing plastic piping unless specifically recommended by the pipe manufacturer.

Leakage may be determined by loss-of-pressure, soap solution, chemical indicator, or positive and accurate method acceptable to the Contractor. All fixtures, devices, or accessories which are to be connected to the lines and which would be damaged if subjected to the specified test pressure shall be disconnected and the ends of the branch lines plugged or capped as required during the testing.

Unless otherwise required by the applicable codes, drainage and venting systems shall be tested by filling with water to the level of the highest vent stack. Openings shall be plugged as necessary. To be considered free of leaks, the system shall hold the water for 30 minutes without any drop in the water level.

Unless otherwise required by the applicable codes, drainage and venting systems shall be tested with compressed air. Openings shall be plugged as necessary, and the system shall be charged with air to a minimum pressure of 5 psig. To be considered free of leaks, the system shall hold the air for 30 minutes without any drop in pressure.

All necessary testing equipment and materials, including tools, appliances and devices, shall be furnished and all tests shall be made by and at the expense of the Subcontractor and at the time directed by the Contractor.

All joints in piping shall be tight and free of leaks. All joints which are found to leak, by observation or during any specified test, shall be repaired, and the tests repeated.

3-10. Cleaning. The interior of all pipe, valves, and fittings shall be smooth, clean, and free of blisters, loose mill scale, sand, dirt, and other foreign matter when installed. Before being placed in service, the interior of all lines shall be thoroughly cleaned, to the satisfaction of the Contractor.

### 3-11. Piping Schedule.

#### 3-11.01 Galvanized Steel Pipe.

- a. ASTM A53 Standard Weight Type E with Threaded Cast Iron Fittings.

All pipe sleeves except where plastic sleeves are required.

- b. ASTM A53 Standard Weight Type E with Threaded Malleable Iron Fittings. All 2 inch and smaller piping for the following services:

Drain piping from equipment.

- c. ASTM A53 Standard Weight Type E with Cast Iron Flanged Fittings. All 2-1/2 inch and larger piping for the following services:

Air stripper air supply piping, 2-1/2 through 5 inches.

Sump pump discharge piping in interior locations except where buried.

Drain piping from equipment.

- 3-11.02 ASTM A312, Grade TP316L Pipe. All 2-inch (unless otherwise noted) and larger piping for the following services:

Process piping where indicated on the drawings.

Untreated groundwater conveyance piping.

Extraction well piping.

- 3-11.03 Black Steel Pipe.

- a. ASTM A53 Standard Weight Type S with Buttwelding Fittings. All 2-1/2 inch (unless otherwise noted) and larger piping for the following services:

Compressed air supply piping.

Cold water supply piping.

- 3-11.04 Copper Water Tubing.

- a. Soft Annealed with Flared Fittings. To be used for piping in contact with earth or submerged.

2 inch and smaller cold water supply piping.

Compressed air supply and pneumatic signal piping.

Differential pressure lines from flowmeters to transmitters.

All instrument piping not otherwise specified.

- b. Hard Drawn with Flanges and Flanged Fittings. To be used inside structures or buildings where flanges are indicated on the drawings.
- c. Hard Drawn with Solder-Joint Fittings. To be used for 3 inch and smaller piping inside structures or buildings.

Cold potable water supply piping.

Differential pressure lines from flowmeters to transmitters.

6.10.5 Copper Instrument Tubing with Compression Fittings. To be used for piping inside structures or buildings.

3/4 inch and smaller panel-mounted compressed air piping.

Pneumatic signal piping.

6.10.6 PVC Pipe, Schedule 80.

- a. With Solvent Welded Joints.

Process piping where indicated on the drawings.

Treated water discharge piping.

Sump pump discharge piping where indicated on the drawings.

- b. With Threaded Joints.

If acceptable to the Contractor, threaded joints may be used instead of solvent welded joints in exposed interior locations to facilitate assembly. The use of threaded joints shall be held to a minimum.

- c. With Flanged or Union Joints. Flanges or unions shall be provided when specified on the drawings at each valve, device, and item of equipment to facilitate disassembly. All other connections, including joining flanges or unions to pipe, shall be solvent welded unless otherwise acceptable to the Contractor.

End of Section



## Section 15100 - MISCELLANEOUS VALVES

### PART 1 - GENERAL

1-1. SCOPE. This section covers all valves, except where specific requirements are stipulated, as in Subcontract Drawing, and in other sections.

1-2. GENERAL EQUIPMENT STIPULATIONS. The General Equipment Stipulations shall apply to all equipment furnished under this section.

1-3. SUBMITTALS. Complete specifications, data, and catalog cuts or drawings covering the items furnished under this section shall be submitted in accordance with Specification Section 01300 - Submittals.

Drawings and data submitted shall include complete connection and schematic wiring diagrams for electric actuators and controls.

### PART 2 - PRODUCTS

#### 2-1. VALVE CONSTRUCTION

2-1.01 Length Tolerance. Unless otherwise specified, the actual length of valves shall be within plus or minus 1/16 inch of the specified or theoretical length.

2-1.02 Ends. Unless otherwise indicated on the drawings or specified, all 3 inch or larger buried valves shall have push-on or mechanical joint ends; all other 2-1/2 inch or larger valves shall have flanged ends; and all 2 inch or smaller valves shall have threaded, solder, or welding ends, as required for the piping system in which the valve is to be installed. Unless otherwise indicated on the drawings, flange diameter and drilling shall conform to ANSI/ASME B16.1, Class 125, or ANSI/ASME B16.5, Class 150. Push-on and mechanical joints shall conform to ANSI/AWWA C111/A21.11. Wafer style valves shall be designed for installation between ANSI Class 125 flanges.

2-1.03 Unions. A union or a flanged connection shall be provided within 2 feet of each threaded end valve unless the valve can be easily removed from the piping.

2-1.04 Shop Painting. All ferrous metal surfaces of valves and accessories, both interior and exterior, shall be shop painted for corrosion protection. The valve manufacturer's standard paint will be acceptable, provided it is functionally equivalent to the specified paint and is compatible with the field painting specified in the painting section.

#### a. Materials.

Asphalt Varnish

Fed Spec TT-C-494.

Medium Consistency Coal Tar	Carboline "Kop-Coat Bitumastic Super Service Black" or Tnemec "46-465 H.B. Tnemecol".
Epoxy For Liquid Service	Ameron "Amerlock 400 High-Solids Epoxy Coating", Carboline "Kop-Coat Super Hi-Gard 891", or Tnemec "Series 140 Pota-Pox Plus".
Rust-Inhibitive Primer	Universal type; Ameron "Amercoat 180 Synthetic Resin Coating" or Carboline "Kop-Coat 340 Gold Primer".
Rust-Preventive Compound	Houghton "Rust Veto 344".

b. Surfaces To Be Painted.

Unfinished Surfaces

Interior Surfaces For Liquid Service	Asphalt varnish (two coats) or epoxy.
Exterior Surfaces of Valves To Be Buried, Submerged, or Installed in Manholes or Valve Vaults	Asphalt varnish or coal tar.
Exterior Surfaces of All Other Valves	Rust-inhibitive primer.
Polished or Machined Surfaces	Rust-preventive compound.
Actuators and Accessories	Rust-inhibitive primer.

## 2-2. MANUAL ACTUATORS

All valves, except those which are equipped with power actuators or are designed for automatic operation, shall be provided with manual actuators. Unless otherwise specified or indicated on the drawings, each manual actuator shall be equipped with an operating handwheel. Use chainwheel operated valves whenever a wheel will be more than 7'-0" above the floor.

2-2.01 Chainwheels. Unless specifically required to be equipped with other types of actuators, all valves with center lines more than 7'-0" above the floor shall be provided with chainwheels and operating chains. Each chainwheel operated valve shall be equipped with a chain guide which will permit rapid handling of the operating chain without "gagging" of the wheel and will also permit reasonable side pull on the chain. Suitable actuator extensions shall be provided, if necessary, to prevent interference of chain and adjacent piping or equipment. Operating chains shall be hot-dip galvanized carbon steel and shall be looped to extend to within 4 feet of the floor below the valve.

2-2.02 Wrench Nuts. Wrench nuts shall be provided on all buried valves, on all valves which are to be operated through floor boxes, and where indicated on the drawings. Unless otherwise directed by the USEPA or the Contractor, all wrench nuts shall comply with Section 3.16 of AWWA C500. At least two operating keys shall be furnished for operation of the wrench nut operated valves.

2-2.03 Operating Stands. Cast iron or fabricated steel operating stands shall be provided in the locations indicated on the drawings. Operating stands shall support the handwheel or lever approximately 36 inches [900 mm] above the floor. Handwheel diameter shall be not less than 8 inches [200 mm]. A sleeve made from standard weight galvanized steel pipe shall be provided for the opening in the floor beneath each operating stand. A suitable thrust bearing shall be provided in each operating stand to carry the weight of the extension stem.

2-2.04 Rotation. Unless otherwise required by the USEPA or the Contractor, the direction of rotation of the wheel, wrench nut, or lever to open the valve shall be to the left (counterclockwise). Each valve body or actuator shall have cast thereon the word "Open" and an arrow indicating the direction to open.

2-3 NUMBER PLATES. Each valve covered by this section which has been assigned a number on the drawings shall be provided with a number plate mounted on or adjacent to the valve in a manner acceptable to the Contractor. Number plates shall be aluminum with engraved letters at least 3/4 inch high. Letters shall be painted black after fabrication.

2-4. CHECK VALVES. Unless otherwise specified, all 2-1/2 inch and larger check valves in water, residuals, or other liquid piping shall be Class 125 horizontal swing type, with iron body and flanged ends. All seats, seat rings, pins, bushings, and other parts subject to wear shall be bronze. Flanges shall be flat faced, with ANSI/ASME B16.1, Class 125 diameter

and drilling. Swing check valves shall be Milwaukee "F-2974", Stockham "G-931" or equal acceptable by the Contractor.

Check valves 2 inches and smaller in water, sludge, or other liquid piping shall be Class 125 or higher, all bronze, Y-pattern, regrinding, horizontal swing type.

Threaded end valves shall be Stockham "B-321", Walworth "Fig 3406" or equal acceptable by the Contractor. Soldered end valves shall be Nibco "S-413-B", Walworth "Fig 3046SJ" or equal acceptable by the Contractor.

Unless specified otherwise, all 2 inch and larger check valves in air or vacuum piping shall be Techno Corporation "Technocheck Silent Seatless Check Valves", Hoffman "Air Check Valves", Lamson "Check Valves", or equal acceptable by the Contractor. Check valves installed in the discharge piping of centrifugal compressors shall be positioned with the valve hinge perpendicular to the impeller shaft of the compressor. Check valves installed in the discharge piping of compressors shall be suitable for an operating temperature of 300°F.

When the compressor discharge pressure exceeds 100 psig, consult the compressed air system designer regarding the check valves to be specified and the temperature ratings of the valves.

Unless specified otherwise, check valves smaller than 2 inches in air and vacuum piping shall be Circle Seal "224B", Nupro "Series C" or equal acceptable by the Contractor.

Unless specified otherwise, check valves in PVC piping shall be PVC ball check valves with Viton seats and seals and socket flanged ends, and shall be Hayward Plastics Products "Ball Check Valve", Nibco "Chemtrol True Union Ball Check Valve" or equal acceptable by the Contractor.

Unless specified otherwise, check valves for vacuum relief service in chemical piping shall be diaphragm type, with two-piece PVC body, Buna-N diaphragm, and threaded ends, and shall be Plast-O-Matic "Series CK Check Valves" or "Series VB Vacuum Breakers", as indicated on the drawings.

2-5. BALL VALVES. Unless otherwise indicated or specified, all 2-1/2 inch [63 mm] and smaller shutoff valves shall be ball valves.

Unless otherwise specified or indicated, two inch and smaller ball valves for air and water service shall be of bronze or brass construction with two-piece end entry body, bronze or brass ball, teflon or Viton stem seal, reinforced teflon seats and thrust washer, a removable operating lever, and threaded ends. Each ball valve in gauge isolation service shall be furnished with a round handle. Valves shall be rated not less than 500 psi [3.4 MPa] nonshock cold WOG and shall be driptight in both directions. Valves shall be Conbraco Industries "Apollo 70-100 Series", Powell "Fig 4210T", or Stockham "S-216".

Two inch and smaller ball valves installed in stainless steel piping shall be of AISI Type 316 stainless steel construction with two-piece end entry body, stainless steel ball, teflon or Viton stem seal, reinforced teflon seats and thrust washer, a removable operating lever, and threaded ends. Each ball valve in gauge isolation service shall be furnished with a round handle. Valves shall be rated not less than 800 psi nonshock cold WOG and shall be driptight in both directions. Valves shall be Conbraco Industries "Apollo 76-100 Series", Neles-Jamesbury "Series 300", or Nibco "580 Series".

Ball valves for air and water service in 2-1/2 inch size shall be ANSI Class 150 regular port valves with split, bolted steel or ductile iron body, hard chrome-plated carbon steel ball, reinforced teflon seats, O-ring or adjustable chevron stem packing, a removable operating lever, and flanged ends. Flange diameter and drilling shall conform to ANSI/ASME B16.5, Class 150. Valves shall be driptight in both directions and shall be Conbraco Industries "Apollo 88-209" or Balon "Series F" ball valves.

Three inch and larger ball valves for air and water service shall be ANSI Class 150 regular port valves with end entry carbon steel body, hard chrome-plated carbon steel ball, reinforced teflon seats, teflon upper and lower stem seal, teflon body seal, a removable operating lever, and flanged ends. Flange diameter and drilling shall conform to ANSI/ASME B16.5, Class 150. Valves shall be driptight in both directions and shall be Conbraco Industries "Apollo 88-100 Series", Neles-Jamesbury "Series 5000, Fig 5150-11-2200TT", or Powell "Fig 4224T" ball valves.

Ball valves 2 inches and smaller for welded steel piping systems shall be of three-piece design, with carbon steel body and end caps, nickel-plated or hard chrome-plated carbon steel ball and stem, teflon seats and seals, socket-weld ends, and a removable operating lever. Socket-weld ball valves shall be rated at least 800 psi nonshock cold WOG and shall be Conbraco Industries "Apollo 83-200 Series", Contromatics "C-1122-BB-DL", or Neles-Jamesbury "4C2200TT".

Ball valves 2-1/2 through 4 inches for welded steel piping systems shall be of three-piece design, with carbon steel body and end caps, nickel-plated or hard chrome-plated carbon steel ball and stem, teflon seats and seals, butt welding ends, and a removable operating lever. Butt welding end ball valves shall be Contromatics "C-1133-BB-DL".

Two inch and smaller ball valves for diesel fuel, fuel oil, gasoline and lubricating oil piping shall be of three-piece design, with carbon steel body and end caps, stainless steel ball, hard chrome-plated stem, reinforced teflon seats and seals, and socket-weld ends. The valves shall be of firesafe design and shall have secondary metal seating surfaces to ensure shutoff if the primary seats are destroyed by fire. Firesafe ball valves shall be Contromatics "C-1122-BB-FS" or Neles-Jamesbury "4C2236TT-1".

All shutoff valves in PVC and FRP piping shall be full-size port PVC ball valves with Viton O-rings, teflon seats, and socket or flanged ends, and shall be Nibco "Chemtrol TU Series Tru-Bloc Ball Valve", Hayward Plastic Products "True Union Ball Valve" or equal acceptable by the Contractor. The port diameter shall be not smaller than the ID of Schedule 80 PVC pipe.

2-6. BUTTERFLY VALVES. Unless otherwise specified, butterfly valves shall be of the rubber-seat, tight-closing type. Except where other types are specified, butterfly valves shall be wafer type. Valve discs shall seat at 90 degrees with the pipe axis.

Flanged end valves shall be of the short-body type. Where mechanical joint ends are specified, either mechanical joint or push-on ends conforming to ANSI/AWWA C111/A21.11 will be acceptable. For buried or submerged service, shaft seals shall be O-ring type.

Each valve shall be provided with an actuator having a torque capability sufficient to seat, unseat, and maintain intermediate positions under the operating conditions specified herein. Lever actuators may be furnished for 6 inch and smaller valves, except where chainwheel actuators are required. All 8 inch and larger valves shall have enclosed, geared, handwheel or chainwheel actuators with position indicator. Actuators shall be designed to produce the rated torque with a maximum pull of 80 pounds on the lever or wheel.

Each valve actuator, except those installed in manholes, buried, or submerged, shall have a valve disc position indicator mounted on the end of the valve shaft. A disc position indicator shall also be provided on each operating stand or the actuator mounted thereon.

## 2-7. HOSE VALVES AND HYDRANTS.

### Interior Locations

#### 3/4 Inch Hose Faucets

Water Piping	Chicago Faucets "No. 7T" or Tanner "1235".
Chemical Piping	PVC ball valve with brass hose thread adapter.
Vacuum Breakers	Nonremovable type; Cash-Acme "Type VB-111", Watts "8AHT", or Woodford "Model 34HD".

#### 1-1/2 Inch Hose Valves

Valve	Class 125 angle valve with bronze body, seat, and disc; screwed bonnet, rising stem, and threaded ends; Milwaukee "504", Stockham "B-216", or Walworth "Fig 3059".
Hose Nipple	One piece, all brass, double male ends, NPT and straight hose thread; Croker Standard "No. 146", Elkhart "No. 306", or Powell "Fig 526"; with cap and chain in exterior locations.

### Exterior Locations

3/4 Inch Wall Hydrants	All brass, freezeproof type; Josam "71200", Smith "5610", Wade "W-8604", Woodford "60", or Zurn "Z-1315".
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## 2-8. THROTTLING VALVES.

2-8.01 Angle Valves. Angle valves shall be furnished where indicated or specified and may also be used as throttling valves for air or water service.

Two inch and smaller angle valves for water service shall be Class 125 valves with bronze body, seat, and disc; screwed bonnet; rising stem; teflon impregnated packing; and threaded ends. Valves shall be Milwaukee "504", Stockham "B-216", or Walworth "Fig 3059".

Two inch and smaller angle valves for air service shall be Class 150 valves with bronze body and seat, composition disc suitable for air service at 250 9F, teflon disc, union bonnet,

rising stem, teflon impregnated packing, and threaded ends. Valves shall be Milwaukee "595", Stockham "B-222", or Walworth "Fig 3096".

Angle valves for air and water service in 2-1/2 inch and larger sizes shall be of cast iron construction with bronze trim, bolted bonnet, outside screw stem and yoke, teflon impregnated packing, and flanged ends. Flanges shall be flat faced with ANSI/ASME B16.1, Class 125 diameter and drilling. Valves shall be Powell "Fig 1254" or Walworth "Fig 8907F".

2-8.02 Globe Needle Valves. For water and air service, throttling valves smaller than 3/4 inch shall be Class 200 globe needle valves of bronze construction with union or screwed bonnet, rising stem, teflon or graphite impregnated packing, and threaded ends. Valves shall be Milwaukee "600", Powell "Fig 180", or Stockham "B-64". Larger throttling valves shall be angle valves or globe valves.

2-8.03 Globe Valves. Globe valves shall be furnished where indicated or specified and may also be used as throttling valves for air or water service.

Two inch and smaller globe valves for water service shall be Class 125 valves of bronze construction with bronze seat and disc, screwed bonnet, rising stem, and teflon impregnated packing. Threaded end valves shall be Milwaukee "502", Stockham "B-16", or Walworth "Fig 3058". Soldered end valves shall be Milwaukee "1502" or Stockham "B-17".

Two inch and smaller globe valves for air service shall be Class 150 valves of bronze construction with bronze seat, teflon disc, union bonnet, rising stem, teflon impregnated packing, and threaded ends. Valves shall be Milwaukee "590", Stockham "B-22", or Walworth "Fig 3095". Soldered end valves shall be Milwaukee "1590", Stockham "B-24", or Walworth "Fig 3095 SJ".

Globe valves for air or water service in 2-1/2 inch and larger sizes shall be of cast iron construction with bronze trim, bolted bonnet, outside screw stem and yoke, teflon impregnated packing, and flanged ends. Flanges shall be flat faced with ANSI/ASME B16.1, Class 125 diameter and drilling. Valves shall be Milwaukee "F2981", Powell "Fig 1253", or Walworth "8096F".

2-9. ELECTRIC VALVES. Valves which are specified or indicated on the drawings to be electrically operated shall be of the following types:

Valve Size (inches)	Type
1 or smaller	Solenoid valve
1-1/2 through 2	Motor operated globe valve or cage valve
2-1/2 and 3	Motor operated globe valve



2-9.01 Solenoid Valves. Solenoid valves shall have brass or bronze bodies and bonnets and packless construction without packing box or sliding seal. Solenoid valves shall be equivalent to the following types listed in ASCO Catalog 32:

Solenoid coils for ac service shall be 230 volts ac, 60 Hz, encapsulated, Class F, for continuous duty at rated voltage plus or minus 10 percent and 40°C ambient, in a NEMA Type 1 enclosure with a conduit knockout.

A strainer shall be provided in the piping immediately upstream from each solenoid valve in water service. Strainers shall be Y-pattern units with brass or bronze body and monel or stainless steel screens. Strainers shall be Cash-Acme "SY", Hoffman Specialty "Model 420", or Wright-Austin "Y". The blowoff from each strainer shall be equipped with a shutoff valve.

2-9.02 Motor Operated Globe and Cage Valves. Motor operated globe and cage valves sized 2 inches and smaller shall be soft seat type with Class 125 pressure rating, cast iron body, single seat, stainless steel trim, and screwed ends. Valves shall be Honeywell Model "1406" or acceptable by the Contractor.

<u>Size</u> inch	<u>Operation</u>	<u>Catalog No.</u>	<u>Minimum</u> <u>Difference</u> <i>psi</i>	<u>Maximum, psi</u>				<u>Orifice</u> <i>inch</i>
				<u>Air</u>		<u>Water</u>		
				<u>ac</u>	<u>dc</u>	<u>ac</u>	<u>dc</u>	
1/4	Normally Closed	DF8262G20	0	360	150	340	125	3/32
1/4	Normally Closed	DF8262G22	0	140	65	165	60	1/8
1/4	Normally Open	DF8262G260	0	750	500	700	500	3/64
1/4	Normally Open	DF8262G261	0	300	200	250	150	3/32
1/4	Normally Open	DF8262G262	0	130	80	110	60	1/8
1/4	Three Way	DF8320G172	0	125	75	130	75	1/16
<i>(Supply pressure on any of 3 connections)</i>								
3/8	Normally Closed	DF8210G1	5	200	125	135	100	5/8
1/2	Normally Closed	DF8210G2	5	200	125	135	100	5/8
3/4	Normally Closed	DF8210G3	5	250	125	150	125	3/4
1	Normally Closed	DF8210G4	5	125	125	125	125	1

Motor operated globe valves sized 2-1/2 inches and larger shall be Class 125 with cast iron body, bronze or stainless steel trim, O-ring sealed cylinder, and flanged ends. Flange diameter and drilling shall conform to ANSI/ASME B16.1, Class 125. Valves shall be Honeywell "Model 8107".

Motor operated globe valves shall be suitable for operation on a 115 volt, 60 Hz, single phase power supply and shall have an actuator cycle time of 30 seconds from fully open to fully closed.

2-10. PRESSURE REDUCING VALVES. Each pressure reducing valve shall be designed to provide tight shutoff under conditions of no flow and shall not "hunt" under ordinary flow conditions. Pressure reducing valves shall be selected and sized as recommended by the valve manufacturer.

2-11. CURB STOPS. Curb stops shall be of bronze construction, tee head type, Ford Meter Box "Ford Ball Valve", Hays "Nuseal Curb Stop", or Mueller "Mark II Oriseal".

2-12. MUD VALVES. Mud valves shall be spigot end, rising stem type, with threaded stem, seat ring, and gate ring of bronze. Each valve shall be provided with coupling nut, extension stem, stem guides, and operating stand, wheel, or wrench nut, as indicated on the drawings. Mud valves shall be installed with the valve seat level.

2-13. SHEAR GATES. Shear gates shall be of cast iron, spigot end frame, with bronze seat rings, and shall be Clow "F-3008". Each gate shall be equipped with a lift handle of proper length for easy operation and shall be provided with a hook support to hold the gate in the fully open position and to support the lever when the gate is in the closed position.

2-14. BACKFLOW PREVENTER. Each backflow preventer shall comply with AWWA C511, shall be of the reduced pressure principle type, and shall consist of a dual check valve assembly with reduced pressure zone between the check valves. A tight-closing shutoff valve shall be provided on each end of the device. Backflow preventers in 2 inch and smaller sizes shall be Cla-Val "Model RP-2", Febco "Model 825Y", Hersey "Beeco Model FRP-II", or Watts "No. 909", with bronze body and threaded end connections. Backflow preventers in 2-1/2 inch and larger sizes shall be Febco "Model 825", Hersey "Beeco Model 6CM", or Watts "No. 909", with cast iron body and flat faced, flanged connections. Flange diameter and drilling shall conform to ANSI/ASME B16.1, Class 125.

2-15. TAPPING SLEEVES AND VALVES. Tapping sleeves and valves shall be furnished and installed where indicated on the drawings. Each tapping sleeve and valve shall be designed for a minimum water working pressure of 150 psi and shall be tested at 300 psi.

With the exception of the valve ends and other modifications necessary for tapping service, tapping valves shall conform to AWWA C500 and shall be Mueller "No. H-667". Each tapping valve shall be provided with a flanged inlet end designed, faced, and drilled for attachment to the outlet flange of the tapping sleeve; an outlet end provided with a tapping flange for attachment of a standard drilling machine; and a mechanical joint type bell end for connection of the branch main.

Tapping sleeves shall be of the flanged outlet type designed for attachment to the flanged inlet end of the tapping valve, and shall be provided with mechanical joint ends at each end of the run. Tapping sleeves shall be Mueller "No. H-615".

2-16. EXTENSION STEMS. Extension stems and stem guides shall be furnished and installed where specified, indicated on the drawings, or otherwise required for proper valve operation. Extension stems shall be of solid steel and shall be not smaller in diameter than the stem of the valve actuator shaft. Extension stems shall be connected to the valve actuator with a single Lovejoy "Type D" universal joint with grease-filled protective boot. All stem connections shall be pinned.

2-17. VALVE BOXES. Each valve buried to a depth of 4 feet or less shall be provided with a slide type valve box. Valve boxes shall be cast iron, extension sleeve type, suitable for the depth of cover indicated on the drawings. Only one extension will be allowed with each slide type valve box. Valve boxes shall be not less than 5 inches in inside diameter, shall be at least 3/16 inch thick at any point, and shall be provided with suitable cast iron bases and covers.

All parts of valve boxes, bases, and covers shall be shop coated by dipping in asphalt varnish.

Top sections and covers for valve boxes which are to be provided with position indicators shall be designed for proper installation of the position indicator and accessories.

### PART 3 - EXECUTION

3-1. INSTALLATION. Each unit shall be leveled, plumbed, and aligned. Installation procedures shall be as recommended by the equipment manufacturer and as specified herein.

3-1.01 Valve Boxes. Valves and valve boxes shall be set plumb. Each valve box shall be placed directly over the valve it serves, with the top of the box brought flush with the finished grade. After each valve box is placed in proper position, earthfill shall be placed and thoroughly tamped around the box.

End of Section

## Section 15140

### PIPE SUPPORTS

#### PART 1 - GENERAL

1-1. SCOPE. This section covers pipe hangers, brackets, and supports. Pipe supports shall be furnished complete with all necessary inserts, bolts, nuts, rods, washers, and other accessories.

This section also covers the spacing of expansion joints in piping systems. Expansion joints are covered in other sections.

1-2. GENERAL. In certain locations, pipe supports, anchors, and expansion joints have been indicated on the drawings, but no attempt has been made to indicate every pipe support, anchor, and expansion joint. It shall be the Subcontractor's responsibility to provide a complete system of pipe supports, to provide expansion joints, and to anchor all piping, in accordance with the requirements set forth herein. Additional pipe supports may be required adjacent to expansion joints, couplings, or valves.

Concrete and fabricated steel supports shall be as indicated on the drawings, as specified in other sections, or, in the absence of such requirements, as permitted by the Contractor.

All piping shall be rigidly supported and anchored so that there is no movement or visible sagging between supports.

Pipe supports and expansion joints are not required in buried piping, but concrete blocking or other suitable anchorage shall be provided as indicated on the drawings or specified in other sections.

1-3. SUBMITTALS. Complete data and catalog cuts or drawings covering fabricated pipe supports, fabricated inserts, and stainless steel, galvanized, and copper- and plastic-coated pipe supports shall be submitted in accordance with the submittals section.

Data shall include a listing of the intended use and general location of each item submitted.

#### PART 2 - PRODUCTS

2-1. MATERIALS. Unless otherwise specified, all pipe supports shall comply with ANSI/MSS SP-58 and MSS SP-69. Materials of construction for fabricated steel supports are covered in the structural and miscellaneous metals section. All pipe support materials shall be packaged as necessary to ensure delivery in satisfactory condition.

Unless otherwise specified or indicated on the drawings, pipe supports shall be fabricated of manufacturer's standard materials and provided with manufacturer's standard finish.

Design loads for inserts, brackets, clamps, and other support items shall not exceed the manufacturer's recommended loads.

Pipe supports shall be manufactured for the sizes and types of pipe to which they are applied. Strap hangers will not be acceptable. Threaded rods shall have sufficient threading to permit the maximum adjustment available in the support item.

Unless otherwise acceptable to the Contractor, the use of supports which rely on stressed thermoplastic components to support the pipe will not be acceptable.

Contact between dissimilar metals, including contact between stainless steel and carbon steel, shall be prevented. Supports for brass or copper pipe or tubing shall be copper plated. Portions of pipe supports which come into contact with other metals that are dissimilar shall be rubber or vinyl coated.

Pipe support types and application shall comply with the Supports Schedule in this section.

### PART 3 - EXECUTION

3-1. APPLICATION. Concrete inserts or L-shaped anchor bolts shall be used to support piping from new cast-in-place concrete. Expansion anchors shall be used to fasten supports to existing concrete and masonry.

Anchorage shall be provided to resist thrust due to temperature changes, changes in diameter or direction, or dead-ending. Anchors shall be located as required to force expansion and contraction movement to occur at expansion joints, loops, or elbows, and as required to prevent excessive bending stresses and opening of mechanical couplings. Anchorage for temperature changes shall be centered between elbows and mechanical joints used as

expansion joints. Anchorage for bellows type expansion joints may be located adjacent to the joint.

Pipe guides shall be provided adjacent to bellows type expansion joints. Guides will not be required where mechanical couplings are permitted as expansion joints. Guides shall be placed on both sides of expansion joints, except where anchors are adjacent to the joint. Unless otherwise indicated on the drawings, one guide shall be within four pipe diameters from the joint and a second guide within 14 pipe diameters from the first guide. Pipe supports shall allow adequate movement; pipe guides shall not be used for support. Pipe guides shall be installed as recommended by the manufacturer.

Pipe supports for insulated cold piping systems shall be sized for the outside diameter of the insulated pipe, and an insulation protection shield shall be installed between the support and the insulation. Rigid insulation inserts shall be installed between the pipe and the insulation shields for piping larger than 2 inches or when required to prevent crushing of the insulation. Inserts shall be of the same thickness as the adjacent insulation and shall be vapor sealed.

Insulated hot piping systems shall be supported by clevises, clamps, support saddles, or rollers. Pipe clamps shall be attached directly to the pipe. Support saddles and rollers shall be sized for the outside diameter of the insulated pipe, and an insulation protection saddle shall be installed at the support.

When supports for the FRP piping systems are in contact with less than 180 degrees of the pipe surface or when the width of the support is less than one-third the nominal pipe diameter (4 inches minimum), an FRP or steel saddle, shaped to the outside diameter of the pipe, shall be bonded to at least the bottom 120 degrees of the pipe.

3-2. LOCATION. Unless closer spacing is indicated on the drawings, the maximum spacing for pipe supports and expansion joints shall be as indicated in the Location Schedule in this section.

Rubber hose and flexible tubing shall be provided with continuous angle or channel support. Unless otherwise indicated on the drawings or acceptable to the Contractor, piping shall be supported approximately 1-1/2 inches out from the face of walls and at least 3 inches below ceilings.

### 3-3. SCHEDULES.

### 3-3.01. Supports Schedule.

<u>Description or Location</u>	MSS SP-69 <u>(Note 1)</u>	Type
		<u>Other</u>
<u>Hangers</u>		
2-1/2 inch and smaller pipe		
For hot and cold insulated piping		
Clevis	1	B-Line "B3100" or Grinnell "260".
Other services		
J-style	5	B-Line "B3690", Grinnell "67", or Unistrut "J Hangers".
Clevis	1	B-Line "B3104" or Grinnell "65".
3 through 10 inch pipe		
For hot insulated piping		
Double bolt	3	B-Line "B3144" or Grinnell "295".
For cold insulated piping		
Clevis	1	B-Line "B3100" or Grinnell "260".
For uninsulated cold piping		
Clamp	4	B-Line "3140" or Grinnell "212".
Clevis	1	B-Line "B3100" or Grinnell "260".
Other services		
Clevis	1	B-Line "B3100" or Grinnell "260" for steel pipe; B-Line "B3102" or



<u>Description or Location</u>	MSS SP-69 <u>(Note 1)</u>	Type
		<u>Other</u> Grinnell "590" for cast iron pipe.
<u>Concrete Inserts, steel</u>		
12 inch and smaller pipe	18	Channel 12 ga, galv, 1-5/8 by 1-3/8 inches, min 8 inches long, anchor lugs on 4 inch centers, at least three lugs, end caps, and filler strip.
<u>Beam Clamps</u> , malleable iron or steel, 12 inch and smaller pipe	21	B-Line "3050" and "3055" or Grinnell "133" and "134".
	28, 29	Grinnell "292".
	30	B-Line "3054" or Grinnell "228".
<u>Side Beam Bracket</u>	34	B-Line "B3062" or Grinnell "202".
<u>Wall Supports and Frames</u> , steel, 12 inch and smaller pipe (Note 2)		
Brackets	32	B-Line "B3066" or Grinnell "195".
	33	B-Line "B3067" or Grinnell "199".
Prefabricated channels	--	12 ga, galv, 1-5/8 by 1-5/8 inches, with suitable brackets and pipe clamps.
Offset pipe clamp, 1-1/2 inch and smaller pipe	--	Galv, 1-1/4 by 3/16 inch steel, with 3/8 inch bolts.
Offset pipe clamp, 2 to 3-1/2 inch pipe	--	Galv, 1-1/4 by 1/4 inch steel, with 3/8 inch bolts.
<u>Floor Supports</u> , steel or cast iron		
6 inch and smaller pipe	37 (with base)	B-Line "B3090" or Grinnell "259".

<u>Description or Location</u>	MSS SP-69 <u>(Note 1)</u>	Type
		<u>Other</u>
8 through 24 inch pipe	38	B-Line "B3093" or Grinnell "264".
<u>Pipe Alignment Guides</u>	--	B-Line "B3281" through "B3287" or Grinnell "255".
<u>Turnbuckles, steel</u>	13	B-Line B3202" or Grinnell "230".
<u>Hanger Rods, carbon steel, threaded both ends, 3/8 inch minimum size</u>	--	B-Line "B3205" or Grinnell "140".
<u>Weldless Eye Nut, steel</u>	17	B-Line "B3200" or Grinnell "290".
<u>Insulation Protection Saddle</u>	39	B-Line "B3160 Series" or Grinnell "160 Series".
<u>Insulation Protection Shield</u>	40	B-Line "B3151" or Grinnell "167".

Notes:

1. MSS SP-69 supports and hangers are illustrated on Figure 1-15140(A) and (B).
2. Pipe clamps or other devices which rely on the application of a clamping force to the supported pipe in order to maintain the clamp position or location in a prefabricated channel or track will not be acceptable for use with nonmetallic pipe or tubing.

### 3-3.02. Location Schedule.

Type of Pipe	Pipe Support Max Spacing	Max Run Without Expansion Joint, Loop, or Bend (Note 1)	Expansion Joint Max Spacing (Note 2)	Type of Expansion Joints
	feet	feet	feet	
Steel				
1-1/4 inch and smaller	7	30	100	Note 3
1-1/2 to 4 inch	10	30	100	Note 3
Over 4 inch	15	30	100	Note 3
Stainless steel				
1-1/4 inch and smaller	7	30	100	Note 3
1-1/2 to 4 inch	10	30	100	Note 3
Over 4 inch	15	80	80	Note 3
Copper, for hot water				
1 inch and smaller	5	20	100	Note 3
Over 1 inch	7	20	100	Note 3
Copper, for other services				
1 inch and smaller	5	--	--	Note 7
Over 1 inch	7	50	100	Note 3

Type of Pipe	Pipe Support Max Spacing	Max Run Without Expansion Joint, Loop, or Bend (Note 1)	Expansion Joint Max Spacing (Note 2)	Type of Expansion Joints
	feet	feet	feet	
PVC, Schedule 80				
1/8 and 1/4 inch	Continuous Support	20	60	Note 3
1/2 inch	3-1/2	20	60	Note 3
3/4 inch	4	20	60	Note 3
1 and 1-1/4 inch	4-1/2	20	60	Note 3
1-1/2 and 2 inch	5	20	60	Note 3
2-1/2 inch	5-1/2	20	60	Note 3
3 inch	6-1/2	20	60	Note 3
4 inch	7	20	60	Note 3
6 inch	8	20	60	Note 3
8 inch	9	20	60	Note 3
10 inch	9-1/2	20	60	Note 3
12 inch	10	20	60	Note 3

Notes:

1. Unless otherwise acceptable to the Contractor, an expansion joint shall be provided in each straight run of pipe having an overall length between loops or bends exceeding the maximum run specified herein.
2. Unless otherwise acceptable to the Contractor, the spacing between expansion joints in any straight pipe run shall not exceed the maximum spacing specified herein.
3. Expansion joint fittings as specified in the miscellaneous piping section.

4. At least two properly padded supports for each pipe section.
5. At least one support for each pipe section.
6. Expansion joints shall be mechanical couplings.
7. No expansion joints are required.
8. Supports for 5 and 10 foot long pipe sections shall be located within 18 inches of each joint. Supports shall be positioned to maintain the piping alignment and to prevent the piping from sagging.

End of Section

## Section 15400 - PLUMBING

### PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing and installation of materials, devices, appliances, fixtures, equipment, and appurtenances required for complete plumbing systems as specified herein and as indicated on the drawings.

Principal items of work to be performed, and materials, equipment, devices, and appliances to be furnished and installed hereunder, include the following:

- a. Drainage and vent piping systems, with connections to each fixture and piece of equipment requiring a waste or vent connection.
- b. Hot and cold building water supply piping systems, including connections to each fixture and piece of equipment requiring water.
- c. Compressed air piping systems, except air supply piping to aeration equipment.
- d. Laboratory piping systems, including connections to laboratory fixtures.
- e. Plumbing fixtures, except those specified in other sections.
- f. Floor drains, cleanouts, bell-ups, and roof drains.

Valves and miscellaneous piping materials are covered in the miscellaneous valves and miscellaneous piping sections, respectively. Piping systems for fuel oil, LP gas, hot water heating, steam heating, and refrigeration are covered in the heating, ventilating, and air conditioning section.

1-2. CODES AND ORDINANCES. Plumbing work shall be performed in accordance with all applicable codes and ordinances which pertain to such work. In case of conflict between these specifications and any applicable code or ordinance, the latter shall govern. In the absence of an applicable plumbing code or ordinance, plumbing work shall conform to the provisions of the Delaware State Building Code.

All gas piping shall be installed in accordance with the recommendations of the National Fire Protection Association.

1-3. SUBMITTALS. Complete specifications, data, and drawings covering all materials, fixtures, and equipment shall be submitted in accordance with the submittals section.

## PART 2- PRODUCTS

2-1. ROOF AND FLOOR DRAINS. Roof and floor drains shall be as manufactured by Josam, Smith, Wade, or Zurn. For ease of identification, the drawings indicate products manufactured by Josam.

Roof drains have threaded or spigot outlets depending on the type of conductor pipes used. Roof drains in precast concrete and metal roof decks shall be equipped with suitable deck clamps. Roof drains shall be securely and rigidly attached to the roof decks to prevent movement and shall be set at a proper level for flashing and drainage.

Floor drains shall be carefully adjusted to the correct elevation for proper drainage. Except at floor drains having integral traps, each floor drain shall be provided with a "P" trap installed as close to the drain as possible.

2-2. PLUMBING FIXTURES AND ACCESSORIES. Plumbing fixtures and accessories shall be provided as indicated on the drawings and as listed herein.

Emergency Shower and  
Eye Wash

Freestanding, with stanchion and floor flange, deluge shower, aerated eye/face wash, delayed action self-closing valves, and interconnecting piping; Speakman "SE-601" with "SE-400" eye/face wash, or Western "9302SS".

Drinking Fountain

Wall-hung, Eaton/Cordley "Model WHA8", Ebco "Oasis Model ODP7M", Halsey-Taylor "WM8A", Haws "HWT-A-8", or Sunroc "Model SO-8C".

Trap

1-1/4 inch rough brass "P" type.

Stop

American-Standard "8204.026", Eljer "801-0780", or Kohler "K-7682".

2-2.01. Supports and Fastenings. Fixtures and accessories shall be securely and rigidly supported. Exposed heads of bolts shall be hexagonal with rounded chromium-plated tops. Chromium-plated hexagonal cap nuts shall be provided to conceal the ends of exposed bolts.

Fasteners for mounting accessories shall be concealed, galvanized, or zinc-plated toggle bolts or expansion anchors.

2-3. PIPING SYSTEMS. All compressed air piping, recovery, conveyance, discharge, well riser, and potable water line piping shall be as specified in Section 15060 – Miscellaneous Piping.

All drainage piping buried beneath floors shall be encased in concrete at least 6 inches thick.

Unless otherwise required by the applicable code, cast iron soil pipe shall be service weight, hubless type. Rubber-gasketed joints may be used if permitted by the applicable code.

### PART 3 - EXECUTION

#### 3-1. PIPING SYSTEMS.

3-1.01. Drainage and Vent Piping. Drainage and vent piping shall be installed where required and shall, in general, conform to the locations indicated on the drawings. Horizontal soil and waste pipes shall have a grade of 1:48 wherever possible, but in no case shall the slope toward the drainage outlet be less than 1:96. Where cleanouts are required in finished floors or in partition walls, a nickel-bronze access cover and frame with securing screw shall be installed over the cleanout plug.

Bell-ups shall be installed with the top rim flush with the floor surface.

Packing box drainage from each pump shall be piped directly from the tapped outlet in the bearing support bracket to a bell-up.

A gauge cock shall be installed in each gauge and vent connection of each pump.



All vents passing through roofs shall be located at least 10 inches (250 mm) from the intersection of a cant with the roof deck, and shall be adequately flashed as indicated on the drawings and as specified in the sheet metal section.

3-1.02. Building Water Supply Piping. Hot and cold building water supply piping shall be installed where required. Suitable connections shall be made to each fixture and piece of equipment requiring water.

Air chambers, or other acceptable water hammer prevention devices, shall be provided on all water supply lines at fixtures and at tops of all risers. Each air chamber shall consist of a piece of pipe not less than 12 nominal pipe diameters in length, with the top end capped and soldered.

3-1.03. Other Piping Systems. Other plumbing systems, including compressed air piping, recovery, conveyance, and discharge piping, shall be furnished and installed as required. Suitable connections shall be made to fixtures and equipment as required.

3-2. SEWERS AND DRAINS. All drainage lines shall be laid on uniformly descending grades. Trenching, embedment, and backfilling shall be as specified in the earthwork section.

Pipe having premolded joints shall be stored and handled so that the joints are not damaged. Joint surfaces shall be properly lubricated immediately before the pipe is installed.

3-3. CLEANING AND ADJUSTING. Immediately prior to the final inspection of the work, all parts of the installation shall be thoroughly cleaned. All equipment, pipe, drains, valves, and fittings shall be cleaned. All valves and other devices shall be adjusted for quiet operation. All drains shall be checked for proper operation.

3-4. PRESSURE AND LEAKAGE TESTING. The entire plumbing system shall be tested for proper operation. This testing shall be initiated without the operation of recovery wells RW-100 through RW-107. Once the proper operation of all wells, pumps, tanks, process equipment and piping has been confirmed and all leaks repaired, all recovery wells and the NAPL removal process shall be tested in conjunction with the rest of the system. The

pressure and leakage testing shall proceed in accordance with Section 3-9 of Specification 15060 Miscellaneous Piping.

End of Section

## Section 15500 - HEATING AND VENTILATING

### PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of heating and ventilating systems, including all equipment, ducts, devices, accessories, and appurtenances necessary for complete, properly operating systems. The Subcontractor shall provide heating, ventilating, and air conditioning systems of adequate capacity to maintain the conditions listed below, based on ASHRAE 1% Summer and 99% Winter outdoor conditions:

	WINTER	SUMMER
Treatment building	50 9F	10 9F above outdoor ambient Not less than 6 air changes per hour

Supports, valves, and accessories which are not an integral part of the equipment or are not specified herein are covered in other sections.

### 1-2. GENERAL.

1-2.01. Coordination. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer unless exceptions are noted by the Contractor.

The Subcontractor shall verify that each component of the system is compatible with all other parts; that all materials, piping, ductwork, fans, and motor sizes are appropriate; and that all devices necessary for a properly functioning system have been provided.

Where two or more units of the same class of equipment are required, they shall be the product of a single manufacturer; however, all the component parts of the system need not be the products of one manufacturer.

Where several manufacturers' names have been listed as possible suppliers, only the products of the first manufacturer listed have been checked for size, functions, and features.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment and materials furnished under this section.

1-2.03. Governing Standards. Except as modified or supplemented herein, all work covered by this section shall be performed in accordance with all applicable local codes and ordinances, laws, and regulations. In case of a conflict between these specifications and any state law or local ordinance, the most stringent shall govern.

All work shall comply with Underwriters' Laboratories (UL) safety requirements.

All work shall comply with the latest edition of Associated Air Balance Council (AABC), National Environmental Balancing Bureau (NEBB), or Sheet Metal and Air Conditioning Contractors National Association (SMACNA) standard manuals for testing, adjusting, and balancing of the air systems.

1-2.04. Power Supply. Unless otherwise indicated, power supply to equipment with motors shall be as specified in the General Equipment Stipulations. Power supply for controls shall be 120 volts, 60 Hz, single phase unless otherwise indicated or required for a properly operating system.

1-2.05 Metal Gages. Metal thicknesses and gages specified herein are minimum requirements. Gages refer to US Standard gage.

### 1-3. SUBMITTALS.

1-3.01. Drawings and Data. Complete assembly and installation drawings, wiring and schematic diagrams, together with detailed specifications and data covering materials, parts, devices and accessories forming a part of the equipment furnished, shall be submitted in accordance with the submittals section. Device tag numbers shall be referenced on the wiring and schematic diagrams where applicable. The data and specifications for each unit shall include, but shall not be limited to, the following:

Fans

Name of manufacturer.

Type and model.

Construction materials, gages, and finishes.

Overall dimensions and required clearances.

Net weight and load distribution.

Performance curves with the specified operating point clearly identified for each unit, type, and model with capacity in cubic feet per minute as the abscissa and brake horsepower, static pressure, and efficiency as the ordinate. The fan curves shall include a family of curves for at least 3 different rotative speeds on a single chart.

Certified AMCA standard test code sound power output data for the fan outlet and casing when operating at the specified volume flow rate. Sound data should list dB re  $10^{-12}$  watts in each octave band, with midrange frequencies starting at 63 Hz and ending at 8,000 Hz.

## Equipment

Name of manufacturer.

Type and model.

Construction materials, gages, and finishes.

Manufacturer's performance data.

Overall dimensions.

Net weight and loading distribution.

Wiring diagrams.

## Temperature Controls System

Published descriptive data on each item of equipment and accessories, indicating all specific characteristics and options and identified with the designation used herein and on the drawings.

Schematic control diagrams giving specific data on all settings, ranges, actions, adjustments, and normal positions. Although schematic, these diagrams shall, as closely as possible, represent the actual system with all significant equipment and devices identified and located relative to each other. These diagrams shall also show detailed multiline wiring, with all terminals accurately identified. Wiring diagrams shall be detailed to the degree required for field construction and shall include all related wiring.

Sequence of operation for each system corresponding to the control schematics.

Space thermostat schedule indicating the types of covers and means of adjustment for each space.

## Equipment Motors.

Manufacturer.  
Type and model.  
Horsepower rating and service factor.  
Temperature rating.  
Full load rotative speed.  
Bearing types and numbers.  
Weight.  
Overall dimensions.  
Full load amperes, efficiency, and power factor.  
Locked rotor current.

1-3.02. Certificate of Compliance. Certificates of compliance shall be submitted as indicated Specification Section 01300 - Submittals.

1-3.03. Operation and Maintenance Manuals. Operation and maintenance instructions shall be provided for the equipment indicated in the equipment schedule and submittals sections. The equipment designations used on the listing shall correspond to those indicated on the drawings.

1-4. QUALITY ASSURANCE. The equipment furnished for installation under this section shall be tested as standard with the manufacturer of the equipment.

Fans shall be rated in accordance with AMCA standards, shall be licensed to bear the AMCA Certified Rating Label and shall be UL listed.

The temperature controls lower-tiered subcontractor shall have at least 3 years' experience in manufacturing and installing the products specified.

Unless otherwise indicated, the controls shall maintain space temperatures within " 2°F of the setpoint.

The adjusting and balancing contractor shall be able to provide experience and qualification data for at least three similar projects.

## PART 2 - PRODUCTS

2-1. SERVICE CONDITIONS. All equipment shall be designed to meet the specified conditions and to operate at the elevation listed in the General Equipment Stipulations.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. Equipment capacities shall be as necessary to maintain the specified ambient building temperatures..

2-3. ACCEPTABLE MANUFACTURERS. Acceptable manufacturers shall be as indicated in the respective product description paragraphs.

#### 2-4. MATERIALS.

2-4.01. Anchor Bolts and Expansion Anchors. All anchor bolts, expansion anchors, nuts, and washers shall comply with the anchor bolts and expansion anchors section.

2-4.02. Equipment Identification. - Not Used

2-4.02.01. Number Plates. All equipment, piping, valves, ductwork, and control equipment denoted by a symbol and an identifying number shall be provided with equipment identification plastic nameplates, plastic tags, metal nameplates, or metal tags.

Plastic nameplates and tags shall be laminated phenolic not less than 1/8 inch thickness and shall be black with white core. Nameplate symbols and numbers shall be capital letter and block with a minimum height as follows:

<u>Item</u>	<u>Letter Height</u> <u>inches</u>
Major Equipment Items	3/4
Minor Equipment Items	1/2

Nameplates shall be twice the letter height by the length required with suitable margins all around. Lettering shall be placed in one row where practicable; however, where required due to excessive length, lettering shall be placed on more than one row and centered.

Metal nameplates and tags shall not be less than 12 gage thickness with engraved or imprinted symbols. Tags shall have smooth edges and shall be a minimum diameter of 1-1/2 inches. Nameplates shall be installed with corrosion-resistant mechanical fasteners. Individual equipment and components too small to accommodate the specified nameplates shall be identified with tags. Tags shall be installed with corrosion-resistant chains or straps.

2-4.02.02. Equipment Plates. In addition to number plates, mechanical equipment shall be identified with engraved or stamped nameplates securely affixed to the equipment in an accessible and visible location. The nameplates shall indicate the manufacturer's name, address, product name, catalog number, serial number, capacity, operating and power characteristics, labels of tested compliances, and any other pertinent design data. The nameplate of the distributing agent only will not be acceptable.

2-4.03. Heaters. Heaters of the types, sizes, and capacities specified herein shall be furnished and installed where indicated on the drawings. All heaters shall be complete with the controls and accessories required for satisfactory operation.

2-4.03.01. Electric Unit Heaters. Electric unit heaters shall be horizontal discharge type and shall include fan and motor assembly, built-in contactor, control transformer, and shall be suitable for use with the available power supply. Heater elements shall be steel plate, fin type with elements brazed to common fins. Each unit heater fan motor shall be provided with automatic reset thermal overload protection. Each unit heater shall be provided with wall mounting brackets and a unit mounted thermostat.

Electric unit heaters shall be Chromalox "LUH," Brasch, or Modine "HE."

2-4.03.02. Wall Heaters. Wall heaters, shall be Brasch "Series FRA", or Electromode. Wall heaters shall be of the downflow type. Each heater shall be designed for surface mounting and shall consist of electric heating element, thermal limit switch, fan delay switch, fan and motor assembly, and a built-in thermostat. The heaters shall be suitable for use with the power supply and shall have the necessary capacity to maintain at least 60 F in the winter.

2-4.04. Fans. Each fan shall be complete with electric drive motor, drive, and accessories as required for satisfactory operation. Belt-driven fans shall be complete with V-belt drive designed for 50 percent overload capacity, adjustable pitch sheaves, adjustable base or rails for belt tightening, and a belt guard. Adjustable sheaves shall be selected so that the fan speed at the specified conditions is at the mid-position of the sheave range. Sheaves shall be replaced with sheaves of the appropriate size after the air system balancing, if necessary, to achieve the fan speed required for the specified airflow.



Fans shall be rated in accordance with AMCA standards, or shall bear the AMCA certified rating label, and shall be UL listed. Fan drive motors and controls shall be as specified in the Electrical paragraph.

2-4.04.01. Roof Exhaust Fan. Roof exhausters shall be belt drive, centrifugal type, and shall be statically and dynamically balanced to ensure quiet, vibration free operation. Each fan shall be complete with a weather hood, safety disconnect switch mounted in the hood, motor operated back draft damper, and ½" mesh bird screens covering all openings. Fan housings shall be aluminum. Fan base shall be aluminum, self-flashing type for mounting on a roof curb. Fan motors shall be open drip proof with permanently lubricated double-sealed ball bearings.

The motor operated damper shall be interlocked with the fan to open when the fan is started and closed when the fan is off.

Roof exhaust fans shall be as manufactured by Penn Ventilator or Loren Cook.

2-4.05. Temperature Controls. Temperature controls shall be the product of a single manufacturer, unless otherwise indicated.

2-4.05.01 Temperature Control Materials. The temperature control components and systems shall be manufactured by Honeywell; Johnson Controls; Landis & Gyr Powers, Inc. All temperature controls shall consist of electrical equipment as specified. Where manufacturers are not specified, the materials and equipment furnished shall meet the performance and design requirements indicated. All control equipment shall be compatible with the control system provided.

The control system shall consist of thermostats and switches in accordance with the operating sequence indicated in the specifications.

2-4.05.02. Thermostats. Thermostats shall be as specified herein.

Ventilation thermostats shall be Honeywell "T631A Airswitch" or Penn Controls "A19BAC-1".

Thermostats shall be two-position, line-voltage type, with a range of approximately 35°F to 100°F with a nonadjustable differential of 29°F. The thermostats shall have an single pole double throw switch rated for 1 horsepower.

2-4.05.03. Accessory Components. All additional control components, including, but not limited to, electric relays, and switches, shall be furnished as required to ensure a complete, properly operating installation and shall be the products of the temperature control equipment manufacturer. Accessory components shall be furnished with equipment enclosures. Relays shall be provided with 120 volt coils and at least 10 ampere contacts.

2-4.05.04. Electrical Wiring. Detailed wiring diagrams shall be submitted in accordance with Specification Section 01300 - Submittals. The wiring diagrams shall show all field wiring to equipment. The wiring diagrams shall be complete, showing all connections necessary to place the temperature control systems in operation.

2-4.6. Tests. All tests shall be conducted in a manner acceptable to the Contractor and shall be repeated as many times as necessary to secure the Contractor's acceptance of each system.

## 2-5. CONSTRUCTION

2-5.01. Shop Painting. Unless otherwise indicated, shop painting shall be as specified in the General Equipment Stipulations. Surface finish damaged during installation shall be repaired to the satisfaction of the Contractor. Field painting shall be as specified in the painting section.

## 2-6. BALANCE

All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that the resonance at normal operating speeds is avoided. In any case, the vibration displacement (peak to peak) as measured at any point on the machine, shall not exceed 2 mils.

At any operating speed, the ratio of rotative speed to the critical speed of a unit or its components shall be less than 0.8 or more than 1.3.

## 2-7. ELECTRICAL

Electric motors and motor controls shall conform to the General Equipment Stipulations. Motor starters and controls shall be furnished and installed under the electrical section, except for equipment with prewired integral starters. Disconnects for equipment shall be furnished and installed under the electrical section, except where specified with integral disconnects. All electrical controls shall have enclosures suitable for the environment and NEMA ratings as indicated on the electrical drawings for wiring in conduit. Prewired electric motors installed in packaged equipment are not required to have clamp type grounding terminals in the conduit box or oversized conduit boxes.

### PART 3 - EXECUTION

#### 3-1. INSPECTION

Equipment installed in existing facilities with limited access shall be suitable for being installed through available openings. The Subcontractor shall field verify existing opening dimensions and other provisions for installation prior to submittal of bids.

#### 3-2. INSTALLATION

Equipment and materials furnished under this section shall be installed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by the Contractor.

3-2.01 Equipment Identification. The installation of identifying devices shall be coordinated with the application of covering materials and painting where devices are applied to surfaces. All surfaces to receive adhesive number plates shall be cleaned before installation of the identification device.

3-2.02 Temperature Controls. Automatic temperature controls shall be furnished and installed as indicated on the drawings and as specified herein.

The Subcontractor shall be responsible for determining that all equipment supplied is suitable for installation in the space indicated on the drawings. Control equipment shall be installed with adequate space for operating and maintenance access.

3-2.03 Thermostats. Wall-mounted thermostats shall be located at 5'-0" above the finished floors. Insulating spacers shall be provided for thermostats mounted on exterior building walls. The spacers shall be installed between the thermostat and its mounting surface, so that the thermostat will not be affected by surface temperatures.

3-2.04 Device Tag Numbering System. All devices shall be provided with permanent identification tags. The tag numbers shall agree with the manufacturer's equipment drawings. All field-mounted control devices shall have identification tags securely fastened to the device. Hand-lettered or tape labels will not be acceptable.

Phenolic nameplates shall be provided and permanently attached to the wall at each control device. The identifying letters used for various equipment shall be the same as the symbols indicated herein and on the drawings. Each nameplate shall have white letters on a black background.

### 3-3. FIELD TESTING

3-3.01 System Adjusting and Balancing. The Subcontractor shall provide the services of a licensed independent contractor, certified by AABC or NEBB, and with proven experience on at least three similar projects, who shall perform operational testing, adjusting, and balancing of the air systems. The total system balancing shall be performed in accordance with AABC, SMACNA, or NEBB Procedural Standards.

All instrumentation shall be calibrated within 6 months and checked for accuracy before testing, adjusting, and balancing the air systems. The instrumentation accuracy shall be not less than specified by the testing, adjusting, and balancing standard manual or by the instrument manufacturer.

Before testing and balancing the air systems, the doors and windows surrounding the areas served by the air system to be balanced shall be closed and the fans shall be checked for correct rotation and rotative speed.

All data, including system deficiencies encountered and corrective actions taken, shall be recorded. If a system cannot be adjusted to meet the design requirements, the Subcontractor shall promptly notify the Contractor in writing.

Following final acceptance of the certified balancing reports, the testing and balancing contractor shall permanently mark the settings of all adjustment devices and shall lock the memory stops.

Air systems shall be adjusted to provide suitable operating temperatures for room spaces.

3-3.02 Completed Systems. After the installation of the heating and ventilating systems has been completed, tests shall be conducted to demonstrate that each system is functioning as specified and to the satisfaction of the Contractor.

3-3.03 Defective Work. If inspection or tests indicate defects, the defective work or material shall be replaced, and inspection and tests repeated.

3-3.04 Cleaning. At the completion of testing, all equipment, pipes, ductwork, valves, and fittings shall be cleaned of grease, debris, metal cuttings, and sludge. Any stoppage, discoloration, or other damage to parts of the building, its finish, or furnishings shall be repaired at no additional cost to the Contractor.

End of Section

## Section 16050 - ELECTRICAL

### PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of all electrical equipment and materials needed for the electrical requirements of this contract.

1-2. GENERAL. Electrical apparatus on all equipment shall be installed complete and placed in readiness for proper operation.

1-2.01. Coordination. Electrical work shall conform to the construction schedule and the progress of other trades.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section.

1-2.03. Anchor Bolts and Expansion Anchors. All anchor bolts, nuts, washers, and expansion anchors shall comply with the anchor bolts and expansion anchors section except smaller than 3/4 inch anchor bolts will be permitted to match NEMA standard size bolt holes on motors and electrical equipment.

1-3. CODES AND PERMITS. All work shall be performed and materials shall be furnished in accordance with the NEC - National Electrical Code, the NESC - National Electrical Safety Code, and the following standards where applicable:

ANSI	-	American National Standards Institute.
ASTM	-	American Society for Testing and Materials.
Fed Spec	-	Federal Specification.
ICEA	-	Insulated Cable Engineers Association.
IEEE	-	Institute of Electrical and Electronics Engineers.
IES	-	Illuminating Engineering Society.
NEMA	-	National Electrical Manufacturers Association.
NFPA	-	National Fire Protection Association.
UL	-	Underwriters' Laboratories.

Equipment covered by this section shall be listed by UL, or by a nationally recognized third party testing laboratory. All costs associated with obtaining the listing shall be the

responsibility of the Subcontractor. If no third-party testing laboratory provides the required listing, an independent test shall be performed at the Subcontractor's expense. Before the test is conducted, the Subcontractor shall submit a copy of the testing procedure to be used.

#### 1-4. IDENTIFICATION.

1-4.01. Conduit. Conduits in manholes, handholes, building entrance pull boxes, junction boxes, and equipment shall be provided with identification tags. Identification tags shall be 19 gauge stainless steel, with 1/2 inch stamped letters and numbers. Identification tags shall be attached to each conduit with nylon tie wraps and shall be positioned to be readily visible.

1-4.02. Cable. Except for lighting and receptacle circuits, each individual wire in power, control, indication, and instrumentation circuits shall be provided with identification markers at the point of termination.

The wire markers shall be of the heat-shrinkable tube type, with custom typed identification numbers. The wire numbers shall be as indicated on the equipment manufacturer's drawings. The wire markers shall be positioned to be readily visible for inspection.

Power wires shall be color coded with electrical tape or colored wire jacket; white neutral, black, and red for 120/240 volt, 3-wire; and white neutral with band of violet tape, brown, orange and yellow for 480/277 volt, 4-wire circuits.

1-4.03. Motor Starters. Motor starters shall be provided with nameplates identifying the related equipment. Pilot controls and indicating lights shall have engraved or etched legends ("start", "stop", etc.). Nameplates shall be laminated black-over-white plastic, with 1/8 inch engraved letters, and shall be securely fastened to the motor starters.

1-4.04. Control Stations. Control stations shall be provided with nameplates identifying the related equipment. Pilot controls and indicating lights shall have engraved or etched legends ("start", "stop", etc.). Nameplates shall be laminated black-over-white plastic, with 1/8 inch engraved letters, and shall be securely fastened to the control stations.

1-4.05. Circuit Breakers. Circuit breakers shall be provided with nameplates identifying related equipment. Nameplates shall be laminated black-over-white plastic, with 1/8 inch engraved letters, and shall be securely fastened to the circuit breakers.

1-4.06. Disconnect Switches. All switches shall have front cover-mounted permanent nameplates that include switch type, manufacturer's name and catalog number, and horsepower rating. An additional nameplate, engraved or etched, laminated black-over-white plastic, with 1/8 inch letters, shall be provided to identify the associated equipment. Both nameplates shall be securely fastened to the enclosure.

1-5. SUBMITTALS. Information covering all materials and equipment shall be submitted for review in accordance with the submittals section. Each sheet of descriptive literature submitted shall be clearly marked to identify the material or equipment as follows:

- a. Lamp fixture descriptive sheets shall show the fixture schedule letter, number, or symbol for which the sheet applies.
- b. Equipment and materials descriptive literature and drawings shall show the specification paragraph for which the equipment applies.
- c. Sheets or drawings covering more than the item being considered shall have all inapplicable information crossed.
- d. Equipment and materials descriptive literature not readily cross-referenced with the drawings or specifications shall be identified by a suitable notation.
- e. Schematics and connection diagrams for all electrical equipment shall be submitted for review. A manufacturer's standard connection diagram or schematic showing more than one scheme of connection will not be accepted, unless it is clearly marked to show the intended connections.

Within 30 days after the Notice to Proceed, the Subcontractor shall furnish a submittal for all types of cable and conduit to be provided. The submittal shall include the cable manufacturer and type, and sufficient data to indicate that the cable and conduit meet the specified requirements.

In addition to the complete specifications and descriptive literature, a sample of the largest size of each type of cable shall be submitted for review before installation. Each sample shall include legible and complete surface printing of the cable identification.



1-6. PROTECTION AND STORAGE. During construction, the insulation on all electrical equipment insulation shall be protected against absorption of moisture, and metallic components shall be protected against corrosion by strip heaters, lamps, or other suitable means. This protection shall be provided immediately upon receipt of the equipment and shall be maintained continuously.

1-7. ELECTRICAL DISTRIBUTION. Electrical service from the utility pole shall be 240 Volt, 3-phase, 3 wire with ground, 60 Hz. 240/120 Volt, 1-phase distribution inside the building shall originate from a wall-mounted panelboard.

## PART 2 - PRODUCTS

2-1. POWER AND TELEPHONE SERVICE ENTRANCES. The Subcontractor shall consult the local electric and telephone utilities regarding their service installation requirements, and shall furnish the service equipment in compliance with these requirements.

Electric service contact is Conectiv Electric Company (Phone) (215) 361-8371. Telephone service contact is Verizon Business Services, (Phone): 1-800-479-1919.

Power service equipment shall include meter board, meter socket, meter test cabinet, metering transformer cabinet, disconnect means, grounding materials, and service entrance fittings required by the utility and for compliance with codes and regulations.

Telephone service provisions shall include a termination box and an empty conduit from the box to a weatherhead at the point of service. The box shall be NEMA Type I, galvanized, surface-mounted, at least 12 by 18 by 6 inches deep, or larger if required. The box shall have a hinged door and an inner mounting board of 3/4 inch exterior plywood, with two coats of varnish. One dedicated telephone lines shall be provided at each treatment building..

A weatherhead shall be provided on each service riser conduit.

2-2. CABLE. The cable furnished shall be produced by one or more of the manufacturers indicated in the following table. All cables of each type (such as lighting cable or 600 volt power cable) shall be from the same manufacturer. Each "X" in the table indicates an acceptable manufacturer of the indicated cable.

	600 V Power <u>Cable</u>	600 V Ltg <u>Cable</u>	Multi-Cond Control <u>Cable</u>	Instrument <u>Cable</u>
American Insulated Wire Corp.	X	X	X	
Belden Electronic Wire & Cable			X	X
BIW Cable System, Inc.	X		X	X
BICC Cables Co.	X		X	X
Cerrowire		X		
Fluorocarbon, Samuel Moore Group, Dekoron Div.			X	X
The Okonite Co.	X		X	
Paranite (Essex)	X	X		
Pirelli Cable Corp.	X			
Rockbestos Co.	X	X	X	X
Rome Cable Corp.	X	X	X	
Service Wire	X	X		
Southwire	X	X		
Tamaqua Cable Products Co.			X	
Triangle PWC, Inc.	X	X	X	

All types of cable shall conform as described herein.

2-2.01. Lighting Cable. Lighting cable shall be provided only in lighting and receptacle circuits operating at 277 volts or less. Lighting and receptacle circuits for underground use and cable 8 AWG or larger shall be as specified for 600 volt power cable.

2-2.02. 600 Volt Power Cable. Cable in power, control, indication, and alarm circuits operating at 600 volts or less, except where lighting, multiconductor control, and instrument cables are permitted or required, shall be 600 volt power cable.

2-2.03. Instrument Cable. Cable for electronic circuits to instrumentation, metering, and other signaling and control equipment shall be two- or three-conductor instrument cable twisted for magnetic noise rejection and protected from electrostatic noise by a total coverage shield.

2-3. CONDUIT. All conduit furnished shall be as described below.

2-3.01. Rigid Steel Conduit. Rigid steel conduit shall be heavy wall, hot-dip galvanized, shall conform to Fed Spec WW-C-581 and ANSI C80.1, and shall be manufactured in accordance with UL 6.

2-3.02. Liquidtight Flexible Metal Conduit. Liquidtight flexible metal conduit shall be hot-dip galvanized steel, shall be covered with a moistureproof polyvinyl chloride jacket, and shall be UL labeled.

2-3.03. Utility (PVC) Duct. Utility duct with concrete encasement shall be polyvinyl chloride (ASTM F-512 designation DB-20) and shall conform to NEMA TC-6 and ASTM F-512.

2-3.04. Rigid Nonmetallic (PVC) Conduit. PVC conduit shall be heavy wall, Schedule 40, UL labeled for aboveground and underground uses, and shall conform to Fed Spec W-C-1094, NEMA TC-2, and UL 651.

2-3. WIRING DEVICES, BOXES, AND FITTINGS. Concealed conduit systems shall have flush-mounted switches and convenience outlets. Exposed conduit systems shall have surface-mounted switches and convenience outlets.

2-4.01. Conduit Boxes and Fittings.

- a. Galvanized or cadmium plated, threaded, malleable iron boxes and fittings shall be manufactured by Crouse-Hinds or Appleton.
- b. Rigid PVC device boxes and fittings shall be manufactured by Carlon.
- c. Sheet steel device boxes shall be manufactured by Appleton or Racor.
- d. PVC coated device boxes shall be manufactured by Ocal, Perma-Cote, or Robroy Industries.
- e. Hub arrangements on threaded fittings shall be the most appropriate for the conduit arrangement to avoid unnecessary bends and fittings.

#### 2-4.02. Device Plates.

- a. Galvanized or cadmium-plated device plates shall be used on surface-mounted outlet boxes where weatherproof plates are not required.
- b. Device plates on flush-mounted outlet boxes where weatherproof plates are not required shall be AISI Type 302 stainless steel, Eagle "93nnn series", Hubbell "S series", or Leviton "840nn-40 series"; nylon or polycarbonate, Eagle "513nV series", Hubbell "Pn series", or Leviton "807nn-I series".
- c. Device plate mounting hardware shall be countersunk and finished to match the plate.
- d. Device plates for switches outdoors or indicated as weatherproof shall have provisions for padlocking switches "On" and "Off", and shall be Appleton "FSK-1VS" or Crouse-Hinds "DS185".
- e. Device plates for weatherproof receptacles shall be Appleton "FSK-WRD" or Crouse-Hinds "WLRD1".
- f. Flush-mounted, weatherproof plates shall be provided with adapter plates, Appleton "FSK-SBA" or Crouse-Hinds "FS031".
- g. Device plates for ground fault interrupter receptacles outdoors shall be Appleton "FSK-WGFI" or Eagle "966".
- h. Engraved device plates, where required, shall be manufactured by Leviton, or equal.
- i. Device plates on PVC conduit fittings shall be Carlon "E98 Series".

#### 2-4.03. Wall Switches.

- a. Switches on ac lighting panel load circuits through 277 volts shall be 20 amperes, 120/277 volts, Eagle "2221V" through "2224V", Hubbell "HBL 1221I" through "HBL 1224I", or Leviton "1221-2I" through "1224-2I".

- b. Switches for pulse control of lighting contactors shall be 15 amperes, 120/277 volts, momentary, double-throw, center "Off", Eagle "1220V", Hubbell "1556I" or Leviton "1256-I".

2-4.04. Receptacles.

- a. Standard convenience outlets shall be duplex, three-wire, grounding, 20 amperes, 125 volts, Eagle "5362V", Hubbell "5362I" or Leviton "5362-I" for 120 volt circuits, and 250 volts, Eagle "5462V", Hubbell "5462I" or Leviton "5462-I" for 240 volt circuits.
- b. Ground fault circuit interrupter receptacles shall be duplex, 20 amperes, 125 volts, Eagle "647-2V", Hubbell "GF5352I" or Leviton "6899-I".

2-4.05. Special Outlets. Clock outlets shall be Hubbell "5235" or Leviton "5261-CH".

2-4. JUNCTION BOXES AND WIRING GUTTERS. Indoor boxes (larger than switch, receptacle, or fixture type) and gutters shall be constructed of sheet steel and shall be galvanized after fabrication. Similar enclosures outdoors shall be provided with neoprene gaskets on the hinged doors or removable covers. Box and gutter sizes, metal thickness, and installation details shall comply with the National Electrical Code.

Bolt-on junction box covers 3'-0" square or larger, or heavier than 25 pounds, shall have rigid handles. Covers larger than 3'-0" by 4'-0" shall be split.

2-6. LIGHTING FIXTURES. Lighting fixtures shall be furnished complete with lamps. Pendant fixtures shall have swivel type box covers and threaded conduit pendants unless otherwise specified.

2-6.01. Electronic Ballasts. Electronic ballasts furnished with fluorescent type lighting fixtures shall be CBM certified as meeting requirements of ANSI C82.11 with a THD level of not more than 10 percent.

2-7. LIGHTING PANELS. Unless otherwise specified, each lighting panel shall be a dead-front, 120/240 volt, single phase panelboard with circuit breakers, in accordance with the following.

2-7.01. Cabinet. The panel shall have a flush-mounted or surface-mounted enclosure with a NEMA designation appropriate for the location where it will be installed. The enclosure shall have a hinged trim (cover). Breaker operating handles shall be accessible through a latched, lockable, door. At the completion of the contract, a neatly printed or typed directory listing the panel and circuit identities shall be mounted inside the door.

2-7.02. Circuit Breakers. Circuit breakers shall be thermal-magnetic, bolt-in, individually front replaceable, and shall indicate "On", "Off", and "Tripped". Breakers indicated as multiple-pole shall be common trip. Breakers shall have interrupting ratings not less than 10,000 amperes. Handle clips to prevent casual operation of breakers shall be provided for 10 percent (at least two) of the breakers and applied to the circuits directed. Breakers and provisions for future breakers shall be provided in the quantities, number of poles, and ampere ratings indicated on the drawings.

2-7.03. Buses. The panel shall have main and neutral buses insulated from the cabinet, and a ground bus. Buses shall be copper, with ampere ratings and main lugs or breaker as indicated. The ground bus shall be similar to a neutral bus and shall have a good ground connection to the cabinet, a removable bond to the neutral bus, clamp type lugs for the ground cable in each supply conduit, and connections for a ground cable in each load conduit.

2-8. POWER PANELS WITH NEUTRALS. Unless otherwise specified, each power panel with neutral shall be dead-front, 3 phase panelboard with circuit breakers, in accordance with the following.

2-8.01. Cabinet. The panel shall have a flush-mounted or surface-mounted enclosure with a NEMA designation appropriate for the location where it will be installed. The enclosure shall have a door with latch and lock. At the completion of the contract, a neatly printed or typed directory listing the panel and circuit identities shall be mounted inside the door.

2-9. SEPARATELY ENCLOSED MOTOR STARTERS. Separately enclosed motor starters, unless otherwise specified, shall be full voltage, magnetic, nonreversing, and NEMA rated. The starter enclosures shall have NEMA type designations appropriate for the locations where they will be installed. Unless otherwise noted, NEMA Type 4X stainless steel enclosures shall be provided for outdoor locations.

One thermal overload relay shall be provided in each phase lead. Each starter shall be provided with an external, manually reset push button for resetting the thermal overload relays.

Each starter shall include auxiliary contacts as required, plus one spare NO and one spare NC contact.

The Subcontractor shall match the sizes of control power transformers, overload devices, heaters, and starters to the equipment furnished, and the environment in which they are located. Control power transformers shall have both primary leads fused, one secondary lead fused, and one secondary lead grounded.

All push buttons, selector switches, and lights indicated on the schematics to be provided on or in the starter enclosure shall be heavy-duty, oiltight type. Push buttons on starters located outdoors shall be provided with protective caps.

2-9.01. Three Phase Starters. Three phase starters shall be circuit breaker combination type consisting of 3 phase, 60 Hz contactors with thermal overloads, a 120 volt ac coil, a dry type control power transformer where required, and a circuit breaker disconnect. Control power transformers shall be sized to handle all simultaneous loads.

Circuit breakers shall be 600 volt magnetic motor circuit protectors for motors smaller than 100 horsepower. Each breaker shall be manually operated with a quick-make, quick-break, trip-free toggle mechanism.

Three phase starters shall be furnished with external manual breaker operating handles and provisions for up to three padlocks. The access door shall be interlocked with the motor circuit protector, so that the door cannot be opened, except by an interlock override, while the breaker is closed.

The complete 3 phase starter shall have an interrupting rating of at least 14,000 amperes at 480 volts.

2-9.02. Single Phase Starters. Single phase starters shall consist of single phase, 60 Hz contactors with thermal overloads and an integral or separately enclosed short-circuit protection device. Starters shall be at least NEMA Size 0, or shall be sized as required to comply with code.

Integral short-circuit protection devices for single phase starters shall be 120/240 volt, magnetic motor circuit protectors.

Separately enclosed short-circuit protection devices for single phase starters shall be molded-case circuit breakers for motor loads 6 amperes and higher and fused switch disconnects for motor loads lower than 6 amperes. Circuit breaker disconnects shall be 120/240 volt, molded-case, thermal-magnetic circuit breakers. Fused switch disconnects shall have quick-make, quick-break mechanisms and 250 volt, dual-element, time-delay fuses.

The short-circuit protection devices shall have external operating handles capable of being padlocked in the open position, and shall have an interrupting rating of at least 10,000 or 22,000 amperes at 120 or 240 volts as required per the available fault current.

2-10. SEPARATELY ENCLOSED MANUAL STARTERS. Separately enclosed manual starters not specified elsewhere shall be provided hereunder. Manual starters shall be provided with thermal overload protection properly sized for the motors served and with a contact and overload in each phase lead. Manual starters shall be mounted in NEMA Type 1 enclosures unless otherwise noted.

2-11. CONTROL STATIONS. Control stations shall be provided as required by the equipment furnished. Pilot devices shall be heavy-duty, oiltight, and shall perform the functions indicated. Indoor control stations shall have NEMA Type 13 enclosures. Control stations outdoors shall have NEMA Type 4 stainless steel enclosures with protective caps on the control devices.

2-12. SEPARATELY ENCLOSED CIRCUIT BREAKERS. Circuit breakers shall be 3 pole, 480 volt, molded-case circuit breakers of not less than 14,000 or 22,000 amperes interrupting rating at 480 volts ac as required per the available fault current, complete with thermal and instantaneous trip elements. Breaker enclosures shall have NEMA designations appropriate for the locations where they will be installed. NEMA Type 4 stainless steel enclosures shall be provided for outdoor locations. Each breaker shall be manually operated with a quick-make, quick-break, trip-free toggle mechanism. Bimetallic thermal elements shall withstand sustained overloads and short-circuit currents without injury and without affecting calibration.



Circuit breakers shall have "On", "Off", and "Tripped" indication and padlockable exterior handles.

2-13. DISCONNECT SWITCHES. Unless otherwise specified, each disconnect switch shall be 3 pole, nonfusible, 600 volts, with a continuous current rating as required by the equipment furnished.

Switches located indoors shall have NEMA type enclosure designations as required by the locations where they will be installed. Switches located outdoors shall have NEMA Type 4 enclosures.

Switches shall have high conductivity copper, visible blades; nontearable, positive, quick-make, quick-break mechanisms; and switch assembly plus operating handle as an integral part of the enclosure base. Each switch shall have a handle whose position is easily recognizable and which can be locked in the "Off" position with three padlocks. The "On" and "Off" positions shall be clearly marked.

All switches shall be UL listed and horsepower rated, and shall meet NEMA KS1-1990. Switches shall have defeatable door interlocks that prevent the door from being opened while the operating handle is in the "On" position.

2-14. LIGHTING AND AUXILIARY POWER TRANSFORMERS. Separately mounted transformers shall be provided in the phases, kVA, and voltages as required. Transformers shall be self-air-cooled, dry type, wall- or floor-mounted, and enclosed for wiring in conduit. Transformers installed outdoors shall be weatherproof. Transformers shall have at least two full capacity voltage taps.

2-15. LIGHTING CONTACTORS. Remote control lighting contactors shall be provided as required. Contactors shall have positive locking features and shall be mechanically held in both positions. Main contacts shall be double-break, continuous-duty rated 20 amperes, 600 volts ac, for all types of loads. Terminals shall accept 18 through 10 AWG conductors. Contactors shall operate in any position and may be manually operated for testing and maintenance. Contactors shall be ASCO 917.

2-16. PHOTOELECTRIC CONTROLS. Photoelectric controls shall be weatherproof, swivel adjustable, with built-in time delay to prevent accidental turnoff by momentary

brightness. The photocell shall be rated 1800 VA, 120 volts ac, and shall be field adjustable from 1 ft/c turnon to 15 ft/c turnoff.

### PART 3 - EXECUTION

3-1. COORDINATION REPORT. The Subcontractor shall coordinate with the power company to determine the available fault current. The Subcontractor shall size all electrical distribution equipment such that the current interrupting capacity exceeds the available fault current.

3-2. POWER AND TELEPHONE SERVICE ENTRANCES INSTALLATION. The Subcontractor shall consult the local electric and telephone utilities regarding their service installation requirements, and shall install the service equipment in compliance with these requirements.

The Subcontractor shall coordinate details and timing of service entrance installations with the utilities.

### 3-3. CABLE INSTALLATION.

3-3.01. General. Except as otherwise specified cable shall be installed according to the following procedures, taking care to protect the cable and to avoid kinking the conductors, cutting or puncturing the jacket, contamination by oil or grease, or any other damage.

- a. Stranded conductor cable shall be terminated by lugs or pressure type connectors. Wrapping stranded cables around screw type terminals is not acceptable.
- b. Stranded conductor cable shall be spliced by crimp type connectors. Twist-on wire connectors may be used for splicing solid cable and for terminations at lighting fixtures.
- c. Splices may be made only at readily accessible locations.
- d. Cable terminations and splices shall be made as recommended by the cable manufacturer for the particular cable and service conditions.

- e. Cable shall not be pulled tight against bushings nor pressed heavily against enclosures.
- f. Cable-pulling lubricant shall be compatible with all cable jackets; shall not contain wax, grease, or silicone; and shall be Polywater "Type J", Quote #1823.
- g. Where necessary to prevent heavy loading on cable connections, in vertical risers, the cable shall be supported by Kellems, or equal, woven grips.
- h. Spare cable ends shall be taped, coiled, and identified.
- i. Cables shall not be bent to a radius less than the minimum recommended by the manufacturer.
- j. All cables in one conduit, over 1 foot long, or with any bends, shall be pulled in or out simultaneously.
- k. Circuits to supply electric power and control to equipment and devices are indicated on the one-line diagrams. Conductors in designated numbers and sizes shall be installed in conduit of designated size. Circuits shall not be combined to reduce conduit requirements unless acceptable to the Engineer.

3-3.02. Underground Cable Pulling Procedure. Care shall be taken to prevent excessive physical stresses that would cause mechanical damage to cables during pulling.

3-4. CONDUIT INSTALLATION. Except as otherwise specified conduit installation and identification shall be done according to the following procedures.

3-4.01. Installation of Interior and Exposed Exterior Conduit. This section covers the installation of conduit inside structures, above and below grade, and in exposed outdoor locations. In general, conduit inside structures shall be concealed. Large conduit and conduit stubs may be exposed unless otherwise specified. No conduit shall be exposed in water chambers.

Unless otherwise indicated on the drawings, the Subcontractor shall be responsible for routing the conduit to meet the following installation requirements:

- a. Conduit installed in all exposed indoor locations shall be rigid steel. Exposed conduit shall be rigidly supported by hot-dip galvanized hardware and framing materials, including nuts and bolts.
- b. Conduit installed in floor slabs and walls, except in hazardous (classified) areas, shall be rigid PVC Schedule 40.
- c. Conduit installed in all exposed outdoor locations shall be rigid steel, rigidly supported by mounting hardware and framing materials. Nuts and bolts shall be rigid steel.
- d. Final connections to dry type transformers, to motors without flexible cords, and to other equipment with rotating or moving parts shall be liquidtight flexible metal conduit with watertight connectors installed without sharp bends and in the minimum lengths required for the application, but not longer than 6'-0" unless otherwise acceptable to the Engineer.
- e. Terminations and connections of rigid steel conduit shall be taper threaded. Conduits shall be reamed free of burrs and shall be terminated with conduit bushings.
- f. Exposed conduit shall be installed either parallel or perpendicular to structural members and surfaces.
- g. Two or more conduits in the same general routing shall be parallel, with symmetrical bends.
- h. Conduits shall be at least 6 inches from high temperature piping, ducts, and flues.
- i. Rigid PVC Schedule 40 conduit shall have supports and provisions for expansion as required by NEC Article 347.
- j. Metallic conduit connections to sheet metal enclosures shall be securely fastened by locknuts inside and outside.

- k. Rigid PVC Schedule 40 conduit shall be secured to sheet metal device boxes using a male terminal adapter with a locknut inside or by using a box adapter inserted through the knockout and cemented into a coupling.
- l. Conduits in walls or slabs which have reinforcement in both faces shall be installed between the reinforcing steel. In slabs with only a single layer of reinforcing steel, conduits shall be placed under the reinforcement.
- m. Conduits that cross structural joints where structural movement is allowed shall be fitted with concretetight and watertight expansion/ deflection couplings, suitable for use with metallic conduits and rigid PVC Schedule 40 conduits. The couplings shall be Appleton type DF, Crouse-Hinds type XD, or O-Z type DX.
- n. Conduit shall be clear of structural openings.
- o. Conduits through roofs or metal walls shall be flashed and sealed watertight.
- p. Conduit installed through any openings cut into concrete or masonry structures shall be neatly grouted.
- q. Conduits shall be capped during construction to prevent entrance of dirt, trash, and water.
- r. Horizontal conduit shall be installed to allow at least 7 feet of headroom, except along structures, piping, and equipment or in other areas where headroom cannot be maintained.
- s. All conduits that enter enclosures shall be terminated with acceptable fittings that will not affect the NEMA rating of the enclosure.
- t. Nonmetallic conduit that turns out of concrete slabs or walls shall be connected to a 90 degree elbows of metallic conduit before it emerges.
- u. Conduits that turn out of concrete floor slabs shall be given a heavy coat of coal tar paint extending 2 inches on each side of the point of turn-out, or a three lap wrap of 4 inch wide 3M Company 51 tape applied over a coat of 3M No. 34548 primer.

- v. Power conductors to and from adjustable frequency drives shall be installed in steel conduit.

3-4.02. Underground Conduit Installation. All excavation, backfilling, and concrete work shall conform to the respective sections of these specifications. Underground conduit shall conform to the following requirements:

- a. All underground conduits shall be concrete encased unless indicated otherwise on the drawings.
- b. Concrete encased conduit shall be rigid schedule 40 (PVC) conduit. Conduits shall have end bells where terminated at walls. All joints shall be solvent welded in accordance with the recommendations of the manufacturer.
- c. Concrete encasement on exposed outdoor conduit risers shall continue to 6 inches above grade, with top crowned and edges chamfered.
- d. Underground conduit bend radius shall be at least 2 feet at vertical risers and at least 3 feet elsewhere.
- e. Underground conduits and conduit banks shall have at least 2 feet of earth cover, except where indicated otherwise.
- f. Underground conduit banks through building walls shall be cast in place, or concreted into boxouts, with water stops on all sides of the boxout. Water stops are specified in the cast-in-place concrete section.
- g. Underground nonmetallic conduits which turn out of concrete or earth in outdoor locations, shall be connected to 90 degree elbows of coal tar painted rigid steel conduit before they emerge.
- h. Conduits not encased in concrete and passing through walls which have one side in contact with earth shall be sealed watertight with special rubber-gasketed sleeve and joint assemblies or with sleeves and modular rubber sealing elements.
- i. Underground conduits shall be sloped to drain from buildings to manholes.

- j. Telephone cables shall not be installed in raceways, conduits, boxes, manholes, or handholes containing other types of circuits.
- k. Intercommunication and instrument cables shall be separated the maximum possible distance from all power wiring in pull-boxes, manholes, and handholes.

3-4.03. Sealing of Conduits. After cable has been installed and connected, conduit ends shall be sealed by forcing nonhardening sealing compound into the conduits to a depth at least equal to the conduit diameter. This method shall be used for sealing all conduits at handholes, manholes, and building entrance junction boxes, and for 1 inch and larger conduit connections to equipment.

3-5. WIRING DEVICES, BOXES, AND FITTINGS INSTALLATION. Metallic and nonmetallic conduit boxes and fittings shall be installed in the following locations:

3-5.01 Conduit Boxes and Fittings.

- a. Galvanized or cadmium plated, threaded, malleable iron boxes and fittings shall be installed in concrete walls, ceilings, and floors; in the outdoor faces of masonry walls; and in all locations where weatherproof device covers are required. These boxes and fittings shall also be installed in exposed metallic conduit systems.
- b. Galvanized or cadmium plated sheet steel boxes shall be installed in the indoor faces of masonry walls, in interior partition walls, and in joist supported ceilings.
- c. Rigid PVC device boxes shall be installed in exposed nonmetallic conduit systems.
- d. Telephone conduit shall be provided with separate junction boxes and pull fittings.

3-5.01. Device Plates. Oversized plates shall be installed where standard-sized plates do not fully cover the wall opening.

3-5.02. Wall Switches.

- a. Wall switches shall be mounted 3'-6" above floor or grade.

- b. After circuits are energized, all wall switches shall be tested for proper operation.

#### 3-5.03. Receptacles.

- a. Convenience outlets shall be 18 inches above the floor unless otherwise required.
- b. Convenience outlets outdoors and in garages, shops, storerooms, and rooms where equipment may be hosed down shall be 4'-0" above floor or grade.
- c. After circuits are energized, each receptacle shall be tested for correct polarity and each GFCI receptacle shall be tested for proper operation.

#### 3-5.04. Special Outlets.

- a. Wall thermostats shall be 4'-6" above the floor unless otherwise required. Thermostats on exterior walls shall be suitably insulated from wall temperature.
- b. Telephone outlets shall be 18 inches above the floor unless otherwise required. Telephone outlets outdoors and shops, storerooms, and rooms where equipment may be hosed down shall be 4'-0" above the floor.
- c. Clock outlets shall be located 7'-0" above the floor.

3-6. EQUIPMENT INSTALLATION. Except as otherwise specified the following procedures shall be used in performing electrical work.

3-6.01. Setting of Equipment. All equipment shall be installed level and plumb. Sheet metal junction boxes, equipment enclosures, sheet metal raceways, and similar items mounted on water- or earth-bearing walls shall be separated from the wall by at least 1/4 inch thick corrosion-resistant spacers.

3-6.02. Sealing of Equipment. All motor control center, and similar equipment shall be permanently sealed at the base, and all openings into equipment shall be screened or sealed with concrete grout to keep out rodents and insects the size of wasps and mud daubers. Small cracks and openings shall be sealed from inside with silicone sealant, Dow-Corning "795" or General Electric "SCS1200".



3-7. GROUNDING. The electrical system and equipment shall be grounded in compliance with the NEC and the following requirements:

- a. All ground conductors shall be at least 12 AWG soft drawn copper cable or bar, bare or green-insulated in accordance with the NEC.
- b. Ground cable splices and joints which will be inaccessible after completion of construction shall meet the requirements of IEEE 837, and shall be Cadweld "Exothermic" or Burndy "Hyground".
- c. Ground cable through exterior building walls shall enter within 3 feet below finished grade and shall be provided with a water stop. Unless otherwise indicated, installation of the water stop shall include filling the space between the strands with solder and soldering a 12 inch copper disc over the cable.
- d. Ground cable near the base of a structure shall be installed in earth and as far from the structure as the excavation permits, but not closer than 6 inches.
- e. Lighting fixtures and receptacles shall be grounded by a copper ground conductor in addition to the conduit connection.
- f. Ground connections to equipment and ground buses shall be made with copper or high conductivity copper alloy ground lugs or clamps. Connections to enclosures not provided with ground buses or ground terminals shall be made with clamp type lugs inserted under permanent assembly bolts or under new bolts drilled and inserted through enclosures, other than explosion-proof, or by grounding locknuts or bushings. Ground cable connections to anchor bolts; against gaskets, paint, or varnish; or on bolts holding removable access covers will not be acceptable.
- g. The grounding system shall be bonded to the station piping by connecting to the first flange inside the building, on either a suction or discharge pipe, with a copper bar or strap. The flange shall be drilled and tapped to provide a bolted connection.
- h. Ground conductors on equipment shall be formed to the contour of the equipment and firmly supported.

- i. Ground rods not described elsewhere shall be 5/8 inch in diameter by 8 feet long, with a copper jacket bonded to a steel core.

3-8. LIGHTING FIXTURE INSTALLATION. The general locations and arrangements of the lighting fixtures shall provide uniform illumination in all areas based on exact location of equipment. Fixtures in rows shall be aligned both vertically and horizontally unless otherwise specified. Fixtures shall be clear of pipes, mechanical equipment, structural openings, indicated future equipment and structural openings, and other obstructions.

3-8.01. Illumination Requirements. The Subcontractor shall perform lighting calculations used to size and arrange lighting fixtures to provide 35 footcandles of illumination in the process area. Lighting fixtures shall be arranged and furnished with diffusers to reduce glare on the computer screen and gauges to a minimum.

End of Section

## Section 16670 - LIGHTNING PROTECTION SYSTEMS

### PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing the design of lightning protection systems and the furnishing and installation of lightning protection equipment for the structures as required.

Lightning protection systems shall be furnished, installed, and tested as specified herein. Lightning protection equipment shall meet the following requirements, and the design conditions and features as required.

Lightning protection systems shall consist of, but not be limited to, air terminals; main, bonding, and down conductors; ground terminals; and all required connectors and fittings required to complete the system.

The lightning protection system shall include the bonding of all roof-mounted mechanical equipment, roof drains, roof mounted ladders, chimneys, antennas, and other roof mounted metal objects.

1-2. GENERAL. Subcontractor shall furnish all installation drawings, tools, equipment, materials, and supplies and shall perform all labor and obtain all inspections to complete the work as specified, and in compliance with all codes, standards, and regulations.

Subcontractor shall provide coordination with other contractors and supervision of installation as needed during construction.

The design of the system shall include determination of the overall lightning hazard for the geographic location of the project and for the structures, the selection of Class I and/or Class II materials, the need of corrosion protection for the copper and/or aluminum components used, and consideration of other pertinent factors. The design shall produce a zone of protection from lightning to prevent personal injury, structural damage, and equipment downtime. The design shall be prepared by a Professional Designer certified by the Lightning Protection Institute (LPI).

Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the Lightning Protection Institute (LPI) unless exceptions are noted by Contractor.

The system shall be installed by a Master Installer certified by LPI.

1-2.01. General Equipment Requirements. Not Used

Lightning protection systems shall be bonded to grounding electrode systems in accordance with the National Electrical Code.

1-2.02. Governing Standards. All equipment furnished under this section shall be designed, constructed, and tested in accordance with ANSI/NFPA 780 - Lightning Protection Code, ANSI/UL 96 - Lightning Protection Components, and LPI 175 - Lightning Protection Institute Standard Practice.

1-2.03. Workmanship and Materials. Subcontractor shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions.

All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, unless required by tests.

1-2.04. Abbreviations. Reference to standards and organizations in the Specifications shall be by the following abbreviated letter designations:

ANSI	American National Standards Institute
NEC	National Electrical Code
NFPA	National Fire Protection Association
LPI	Lightning Protection Institute
UL	Underwriters' Laboratories

1-3. SUBMITTALS. Complete certification of design calculations; assembly, and installation drawings; together with complete engineering data covering the materials used and the parts, devices, and accessories forming the system, shall be submitted in accordance with the submittals section.

1-4. QUALITY ASSURANCE. The lightning protection system shall be inspected and tested after installation by conducting continuity and ground resistance tests as well as a visual inspection. Inspection results and test data shall be submitted in accordance with the submittals section. Subcontractor shall provide the services of an LPI Certified Inspector, independent of the System Designer, who shall inspect the system at each stage of construction recommended by LPI. This Certified Inspector shall serve as Owner'S agent during the LPI certification process. Subcontractor shall furnish an LPI

Certified System nameplate on each structure/building. The nameplate shall be attached to the building at a location approved by Owner.

## PART 2 - PRODUCTS

2-1. ACCEPTABLE MANUFACTURERS. The system components shall be manufactured by a company that has been specializing in the manufacture of lightning protection equipment for at least 5 years and is a member of LPI.

2-2. MATERIALS. All manufactured and fabricated components shall conform to NFPA 780 Class I or Class II as needed for the structures on which they will be installed. The system components shall be fabricated from the following metals:

Conductors	Copper.
Air Terminals	Copper or bronze.
Grounding Electrodes	Copper clad steel.
Fasteners	Copper or bronze.
Bimetallic Fasteners	Bronze and aluminum.

Aluminum conductors and air terminals shall be mounted on aluminum surfaces only.

All materials furnished for the lightning protection system shall bear the inspection label of UL.

## PART 3 - EXECUTION

3-1. INSTALLATION. The lightning protection system shall be installed in a neat and inconspicuous manner so all components will blend in with the appearance of the building. All conductors shall be concealed or semi-concealed during construction using methods recommended in NFPA 780.

Air terminals shall have base supports designed for the surface on which they are used and shall be securely anchored. All exposed metal eave troughs, roof vents, guy wires, antennas, and air handling equipment shall be bonded to the lightning protection system in such a way that two paths to ground are provided.

The lightning protection system shall be bonded to structure/building electrical ground rings wherever they are available.

End of Section

## Section 16721

### FIRE DETECTION AND ALARM SYSTEM

#### PART 1 - GENERAL

1-1. SCOPE. This section covers the furnishing and installation of a fire detection and alarm system, including all associated equipment, devices, and controls necessary for proper operation.

1-2. GENERAL. The Contractor shall furnish all installation drawings, tools, equipment, materials, and supplies and shall perform all labor to complete the work as specified, and in compliance with the codes, standards, and regulations listed below.

The design of the system shall consist of, but shall not be limited to, an analysis of the various plant ambient noise levels and environments (wet, dusty, oily, corrosive, hazardous, etc.); the number of detectors, notification appliances, and manual stations required; and the proper wiring and mounting configurations.

1-2.01. System Supplier's Qualifications. The system design, equipment, and installation furnished under this section shall be provided by a single manufacturer or supplier who has been engaged in the business of supplying fire alarm systems of this type for at least 2 years.

1-2.02. General Equipment Stipulations. The General Equipment Stipulations shall apply to all equipment furnished under this section.

1-2.03. Governing Standards.

- a. North Carolina State Fire Marshal's Regulations for Safety to Life from Fire and Emergencies in Buildings and Structures, and General Fire Protection.
- b. National Fire Protection Association, NFPA 72.
- c. National Electrical Code, Article 760.

The system shall be listed by Underwriters' Laboratories.

1-2.04. Nameplates. Major components of equipment shall be identified with a permanently affixed nameplate bearing the manufacturer's name and address, and type or style and catalog number of the item.

1-2.05. Tags. Keys and locks shall be furnished with tags bearing stamped identification numbers. Cable and conduit runs, wiring circuits, and all spare parts supplied to maintain the system shall be furnished with hard phenolic or stainless steel tags. Four keys shall be provided.

1-2.06. Power Requirements. Power supply to the fire alarm control panel (FACP) will be 120 volts, 60 Hz, single phase.

The alarm system shall include an automatically recharged backup power supply with sufficient battery capacity to operate the entire system in the normal supervisory mode for 24 hours and then sound all alarms for 5 minutes. In the event of power failure, the system shall automatically transfer to the standby batteries.

All external circuits requiring system operating power shall be suitable for 24 volt dc service and shall be individually fused at the control panel.

1-2.07. Spare Parts. The following spare parts shall be supplied with the fire detection and alarm system. Spare parts shall be suitably packaged for shipment.

- 1 - Each type of smoke detector and heat detector.
- 1 - Each type of manual pull station and audiovisual alarm.

1-3. SUBMITTALS. Complete electrical wiring diagrams; assembly and installation drawings; detailed specifications; and data covering the materials used and the parts, devices, and other accessories forming a part of the equipment furnished shall be submitted in accordance with the submittals section.

In addition to the submittals to the Engineer, the Contractor shall submit complete plans and information to the local fire department for review. The equipment submittals shall include the following:

- Complete description of all system components, including certification of listing by UL.

- Complete sequence of operation for all functions of the system.
- Location drawings for all controls, alarm initiating devices, and alarm notification devices.
- Listing of the manufacturer's representatives responsible for installation and service.
- Operation and maintenance manuals.

1-4. SYSTEM DESCRIPTION. The fire detection and alarm system shall be operated and monitored by a fire alarm control panel (FACP). The system shall automatically initiate fire alarm signals whenever any manual or automatic fire detection device is placed in an alarm mode. The system shall identify the devices and their locations and transmit a signal to the local fire department and the Subcontractor. The FACP shall sound local alarms for detection device alarm conditions, system trouble, or circuit failure. The operation of any alarm initiating device shall cause audible and visual alarms to sound and to be displayed throughout the building. A key-accessible reset function shall reset the alarm system after alarm initiating conditions have been cleared.

1-4.01. Fire Alarm System.

- a. The system shall include heat detectors, smoke detectors, audiovisual devices, manual pull stations, wiring connections to devices, outlet boxes, junction boxes, and all other necessary equipment for a complete operating system.
- b. System trouble, including grounded or open supervised circuit, power failure, system battery low voltage, or system failure, shall cause the system to enter a trouble mode and display visual and audible alarms. The visual alarm shall be displayed until the initiating trouble has been cleared.
- c. A dedicated circuit connected to the line side of the incoming electrical service shall be provided to supply power to building fire alarm system.
- d. The alarm sequence initiated by the activation of any manual station or automatic detection device shall be as follows:



- (1) Selected audible alarm notification devices sound until silenced by the alarm silence switch at the FACP.
- (2) Selected visual alarm indicating devices display a continuous strobe pattern until the system is reset.
- (3) A supervised signal to notify the local fire department and the Subcontractor.

1-4.02. Fire Alarm System Configuration. Alarm initiation circuits shall be configured in a Style B configuration in accordance with NFPA 72. Notification alarm circuits shall be configured in a Style Z configuration in accordance with NFPA 72.

1-5. SYSTEM COMPONENTS. All fire alarm equipment and materials, devices, and assemblies shall be UL listed. The equipment shall not be altered, installed, or modified in any way that would void the listing.

All control equipment shall have transient voltage protection devices in compliance with UL 864.

The system controls shall be UL listed for Power Limited Applications according to NEC 760. All circuits shall be marked in accordance with NEC 760-23.

Peripheral components as specified shall be provided in sufficient number and located as required to meet all applicable codes.

## PART 2 - PRODUCTS

2-1. CONTROL PANEL. Panel shall be modular, installed in a surface mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly assembled panel containing components and equipment required to provide the specified operating and supervisory functions of the system. The panel shall have prominent rigid plastic, phenolic, or metal identification plates for LEDs, zones, controls, meters, fuses, and switches. Nameplates for fuses shall also include ampere rating. Separate alarm and trouble LEDs shall be provided for each zone alarm. These LEDs shall be located on the exterior of the cabinet door or be visible through the cabinet door. Control panel switches shall be within the locked cabinet. A suitable means (single operation) shall be provided for

testing the control panel visual indicating devices (meters or LEDs). Meters and LEDs shall be plainly visible when the cabinet door is closed. Signals and LEDs shall be provided to indicate by zone any alarm, supervisory, or trouble condition on the system. Each IDC shall be powered and supervised so that a signal on one zone does not prevent the receipt of signals from other zones. Loss of power, including batteries, shall not require the reloading of a program. Upon restoration of power, startup of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory, or trouble signals. Visual annunciators shall be provided for each active zone and spare zone. Each LED shall provide specific identification of the zone by means of a permanently attached rigid plastic, phenolic, or metal sign with either raised or engraved letters. Zone identification shall consist of a space to allow proper clearance between the cabinet and live parts of the panel equipment.

2-1.01. Circuit Connections. Circuit conductors entering or leaving the panel shall be connected to screw-type terminals with each conductor and terminal marked for identification.

2-2. STORAGE BATTERIES. Storage batteries shall be provided and shall be 24 Vdc sealed, gel-cel type requiring no additional water. The batteries shall have ample capacity, with primary power disconnected, to operate the fire alarm system for a period of 24 hours. Following this period of battery operation, the batteries shall have ample capacity to operate all components of the system, including all alarm signaling devices in the total alarm mode for a minimum period of 5 minutes. Batteries shall be located at the bottom of the panel. Batteries shall be provided with overcurrent protection in accordance with NFPA 72.

2-3. BATTERY CHARGER. Battery charger shall be completely automatic, 24 Vdc with high/low charging rate, capable of restoring the batteries from full discharge (18 Volts dc) to full charge within 48 hours. A pilot light indicating when batteries are manually places on a high rate of charge shall be provided as part of the unit assembly, if a high rate switch is provided. Charger shall be located in control panel cabinet or in a separate battery cabinet.

2-4. MANUAL FIRE ALARM STATIONS. Stations shall be installed on surface mounted outlet boxes. Manual stations shall be mounted at 48 inches. Stations shall be single action type. Stations shall be finished in red, with raised letter operating instructions of contrasting color. The use of a key or wrench shall be required to reset the station. Gravity or mercury switches are not acceptable. Switches and contacts shall be rated for the voltage and current upon which they operate. Stations shall have a separate screw terminal for each conductor.

2-5. FIRE DETECTING DEVICES. Detector base shall have screw terminals for making connections. No solder connections will be allowed. Installed devices shall conform to the NFPA 70 hazard classification of the area where devices are to be installed.

2-5.01. Heat Detectors. Detectors shall be designed for surface outlet box mounting and supported independently of wiring connections. Contacts shall be self-resetting after response to rate-of-rise principle. Under fixed temperature actuation, the detector shall have a permanent external indication which is readily visible. The rating for the fixed temperature portion shall be 135 degrees F. The rating for the Rate-of-Rise detectors shall be 10 degrees F per minute.

2-5.02. Smoke Detectors. Smoke detectors shall be photoelectric type. Detectors shall contain a visible indicator LED that shows when the unit is in alarm condition. Detectors shall not be adversely affected by vibration or pressure. Detectors shall operate on a light scattering concept using an LED light source. Failure of the LED shall not cause an alarm condition. Detectors shall be factory set for sensitivity and shall require no field adjustments of any kind.

2-6. NOTIFICATION APPLIANCES. Devices shall have a separate screw terminal for each conductor. Audible appliances shall generate a unique sound from other devices provided in the building and surrounding area.

2-6.01. Alarm Horns. Horns shall be surface mounted, with the matching mounting back box surface mounted and suitable for use in an electrically supervised circuit. Horns shall produce a sound rating of at least 15 dBA above ambient sound levels.

2-6.02. Visual Notification Appliances. Appliances shall have clear high intensity optic lens, xenon flash tubes, and output white light. Strobe flash rate shall be between 1 to 3 flashes per second and a minimum of 75 candela. Strobe shall be surface mounted.

2-6.03. Combination Audible/Visual Notification Appliances. Combination audible/visual notification appliances shall provide the same requirements as individual units, except that they shall mount as a unit in standard backboxes. Units shall be factory assembled.

2-6.04. Remote Notification. System shall be configured to interface with the treatment system's supervisory control and data acquisition (SCADA) system and initiate an alarm call out in the event of fire or system fault.

## 2-7. FIRE DETECTION AND ALARM SYSTEM PERIPHERAL EQUIPMENT.

2-7.01. Conduit. All fire alarm wiring shall be installed in conduits.

2-7.02. Wiring. Wiring for 120 VAC power shall be No. 12 AWG minimum. Wiring for Fire Alarm circuits shall be No. 16 AWG minimum. Voltages shall not be mixed in any junction box, housing, or device. System field wiring shall be solid copper and installed in metallic conduit or electrical metallic tubing. Conductors shall be color coded. Conductors used for the same functions shall be similarly color coded. Wiring code color shall remain uniform throughout the circuit. Pigtail or T-tap connections to initiating device circuits and notification appliance circuits are prohibited.

## PART 3 - EXECUTION.

3-1. INSTALLATION. All work shall be installed as shown and in accordance with the manufacturer's diagrams and recommendations, unless otherwise specified. Smoke detectors shall not be installed until construction is essentially complete and the building has been thoroughly cleaned.

3-1.01. Power Supply for the System. A single dedicated circuit connection for supplying power from a branch circuit to the building fire alarm system shall be provided. The power supply shall be equipped with a locking mechanism and marked in red with the words "FIRE ALARM CIRCUIT CONTROL."

3-1.02. Wiring. Conduit size for wiring shall be in accordance with NFPA 70. Wiring for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting and power systems. Not more than two conductors shall be installed under any device screw terminal. The wires under the screw terminal shall be straight when placed under the terminal then clamped in place under the screw terminal. The wires shall be broken and not twisted around the terminal. Circuit conductors entering or leaving any mounting box, outlet box enclosure, or cabinet shall be connected to screw terminals with each terminal and conductor marked in accordance with the wiring diagram. Connections and splices shall be made using screw terminal blocks. The use of wire nut type connectors

in the system is prohibited. Wiring within any control equipment shall be readily accessible without removing any component parts. The fire alarm equipment manufacturer's representative shall be present for the connection of wiring to the control panel.

3-1.03. Control Panel. The control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than 12 inches nor more than 78 inches above the finished floor. Manually operable controls shall be between 36 and 42 inches above the finished floor. Panel shall be installed to comply with the requirements of UL 864.

3-1.04. Detectors. Detectors shall be located and installed in accordance with NFPA 72. Detectors shall be at least 12 inches from any part of any lighting fixture. Detectors shall be located at least 3 feet from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location. Detectors which mount in open space shall be mounted directly to the end of the stubbed down rigid conduit drop. Conduit drops shall be firmly secured to minimize detector sway. Where length of conduit drop from ceiling or wall surface exceeds 3 feet, sway bracing shall be provided.

3-1.05. Notification Appliances. Notification appliances shall be mounted 80 inches above the finished floor or 6 inches below the ceiling, whichever is lower.

### 3-2. OVERVOLTAGE AND SURGE PROTECTION.

3-2.01. Power Line Surge Protection. All equipment connected to alternating current shall be protected from surges per IEEE C62.41 B3 combination waveform and NFPA 70. Fuses shall not be used for surge protection. The surge protector shall be rated for a maximum let thru voltage of 350 Volts ac (line-to-neutral) and 350 Volts ac (neutral-to-ground).

3-3. GROUNDING. Grounding shall be provided by connecting to building ground system.

3-4. TESTING. The Contractor shall notify the Contracting Officer at least 10 days before the preliminary and acceptance tests are to be conducted. The tests shall be performed in accordance with the approved test procedures in the presence of the Contracting Officer. The control panel manufacturer's representative shall be present to supervise the tests. The Contractor shall furnish instruments and personnel required for the tests.

3-4.01. Preliminary Tests. Upon completion of the installation, the system shall be subjected to functional and operational performance tests including tests of each installed

initiating and notification appliance, when required. Tests shall include the meggering of system conductors to determine that the system is free from grounded, shorted, or open circuits. The megger test shall be conducted prior to the installation of fire alarm equipment.

If deficiencies are found, corrections shall be made and the system shall be retested to assure that it is functional. After completing the preliminary testing the Contractor shall complete and submit the NFPA 72, Certificate of Completion.

3-4.02. Acceptance Test. Acceptance testing shall not be performed until the Contractor has completed and submitted the Certificate of Completion. Testing shall be in accordance with NFPA 72. The recommended tests in NFPA 72 shall be considered mandatory and shall verify that previous deficiencies have been corrected. The Contractor shall complete and submit the NFPA 72, Inspection and Testing Form. The test shall include all requirements of NFPA 72 and the following:

- a. Test of each function of the control panel.
- b. Test of each circuit in both trouble and normal modes.
- c. Tests of each alarm initiating devices in both normal and trouble conditions.
- d. Tests of each control circuit and device.
- e. Tests of each alarm notification appliance.
- f. Tests of the battery charger and batteries.
- g. Complete operational tests under emergency power supply.
- h. Visual inspection of wiring connections.
- i. Opening the circuit at each alarm initiating device and notification appliance to test the wiring supervisory feature.
- j. Ground fault.
- k. Short circuit faults.
- l. Stray voltage.
- m. Loop resistance.

End of Section

## SECTION 16901 - CONTROL SYSTEM

### PART 1 - GENERAL

1-1. SCOPE. This section covers furnishing and installation of a personal computer (PC), video display, keyboard, inkjet printer, programmable logic controller (PLC), input logic modules, output logic modules, rack assemblies, modem, control cabinets, power supplies, communications cable, software, and all other required accessories for a functioning control system as described in this section and as indicated on the drawings. Subcontractor shall provide a complete and working system including design based on actual control equipment furnished as well as furnished plant process equipment. Subcontractor shall design, coordinate, install, program and test equipment in accordance with the provisions and control sequence described in this and other specification sections, and shall engage a system supplier subcontractor, referred to as "System Supplier" to perform these tasks.

1-2. GENERAL. Equipment furnished and installed under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the equipment manufacturer, unless exceptions are noted by Contractor.

1-2.01. General Equipment Requirements. As required, the General Equipment Requirements shall apply to all equipment provided under this section.

The supplier shall have as a minimum 5 years experience in the design, coordination and supply of computer-based monitoring, control, and data acquisition systems.

1-2.02. Codes, Permits and Agency Approvals. All work performed and all materials used shall be in accordance with the 2002 National Electrical Code (NEC), and with applicable local regulations and ordinances. Where mandated by codes, panels, assemblies, materials, and equipment shall be listed by Underwriters' Laboratories (UL) or other testing organizations acceptable to the governing authority as required. Subcontractor shall, as part of their work, arrange for and obtain all necessary permits, inspections, and approvals by the authorities having local jurisdiction of such work. This shall include any third-party inspections and testing of panels and equipment. Equipment

furnished under this section shall be designed, constructed, and tested in accordance with Institute of Electrical and Electronics Engineers (IEEE) 519, American National Standards Institute (ANSI) C37.90, Federal Communications Commission (FCC) Part 15 - Class A, and National Electrical Manufacturers Association (NEMA) ICS-1-109.60.

1-2.03. Coordination. Systems supplied under this section shall be designed and coordinated by Subcontractor for proper operation with related equipment and materials furnished by other suppliers under other sections of these specifications, under other contracts, and, where applicable, with related existing equipment. All equipment shall be designed and installed in full conformity with the drawings, specifications, engineering data, instructions, and recommendations of the manufacturer, and the manufacturer of the related equipment.

1-2.04. Related Equipment and Materials. Related equipment and materials may include, but will not be limited to, instrumentation, motor controllers, valve actuators, chemical feeders, analytical measuring devices, conduit, cable, and piping as described in other sections or furnished under other contracts.

1-3. GENERAL REQUIREMENTS. The drawings and specifications indicate the extent and general arrangement of the systems. If any departures from the drawings or specifications are deemed necessary by Subcontractor, details of such departures and the reasons shall be submitted to Contractor for review with or before the first stage or conceptual submittals. No departures shall be made without prior written acceptance.

The specifications describe the minimum requirements for hardware and software. Where Subcontractor's standard configuration includes additional items of equipment or software features not specifically described herein, such equipment or features shall be furnished as a part of the system and shall be warranted as specified herein.

1-3.01. Governing Standards. Equipment furnished under this section shall be designed, constructed, and tested in accordance with IEEE 519, ANSI C37.90, FCC Part 15 - Class A, and NEMA ICS-1-109.60.

1-3.02. Dimensional Restrictions. Layout dimensions will vary between manufacturers and the layout area indicated on the drawings is based on typical values. The Subcontractor shall review the contract drawings, the manufacturer's layout drawings and



installation requirements, and make any modifications necessary for proper installation subject to acceptance by Contractor. At least three feet of clear access space shall be provided in front of all components of the computer control system components.

1-3.03. Workmanship and Materials. Subcontractor shall guarantee all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage, or other failure. Materials shall be suitable for service conditions. This warranty period shall be for a minimum of 30 months and shall begin upon satisfactory completion of final site acceptance tests of equipment and materials; warranty time shall not be included in calendar days for completion.

All equipment shall be designed, fabricated, and assembled in accordance with recognized and acceptable engineering and shop practice. Individual parts shall be manufactured to standard sizes and thicknesses so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except for testing.

1-3.04. Abbreviations. Reference to standards and organizations in the Specifications shall be by the following abbreviated letter designations:

ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AWG	American Wire Gage
FCC	Federal Communications Commission
IEEE	Institute of Electrical and Electronics Engineers
ISA	Instrument Society of America
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
UL	Underwriters' Laboratories

1-4. SUBMITTALS. Complete dimensional, assembly, and installation drawings, wiring and schematic diagrams; and details, specifications, and data covering the materials used and the parts, devices and accessories forming a part of the system furnished, shall be submitted in accordance with the submittals section.

1-4.01. Control System. Submittal data shall be grouped and submitted in three separate stages. The submittal for each stage shall be substantially complete. Individual drawings and data sheets submitted at random intervals will not be accepted for review. Equipment tag numbers or identifications used on the drawings shall be referenced where applicable.

1-4.01.01. First Stage Submittal. The first stage submittal shall include the following items.

a.	A detailed list of any exceptions, functional differences, or discrepancies between the system proposed by Subcontractor and this specification.
b.	Product catalog cut sheets on all hardware items, clearly marked to show the model number, optional features, and intended service of each device.
c.	A brief, concise description of the proposed system, including major hardware and software components, field services, and personnel training.
d.	A block diagram or schematic drawing showing the principal items of equipment furnished, including model numbers, and their interrelationships.
e.	Drawings showing floor space or desktop area requirements for all equipment items, including allowances for door swings and maintenance access.
f.	Environmental and power requirements, including heat release information for each equipment item.
g.	Standard system engineering and user manuals describing the use of the system and application programming techniques for creating reports, graphics, database, historical records, and adding new process I/O nodes to the system.
h.	Standard field termination drawings for all process input/output equipment, showing typical terminations for each type of point available in the system.
i.	A copy of the proposed software licenses for all software associated with the

	system.
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1-4.01.02. Second Stage Submittal. Before any equipment is released for shipment to the site and before factory testing is scheduled, the following data shall be submitted.

At Subcontractor's option, the first and second stage submittals may be combined.

a.	Detailed functional descriptions of all software modules specified and furnished as part of Subcontractor's standard system. The descriptions shall be identified with the applicable specification paragraph.
b.	Complete panel fabrication drawings and details of panel wiring, piping, and painting. Panel and subpanel drawings shall include overall dimensions, metal thickness, door swing, mounting details, weight, and front of panel arrangement to show general appearance, with spacing and mounting height of instruments and control devices.
c.	Wiring and installation drawings for all interconnecting wiring between components of the system and between related equipment and the equipment furnished under this section. Wiring diagrams shall show complete circuits and indicate all connections. If panel terminal designations, interdevice connections, device features and options, or other features are modified during the fabrication or factory testing, revised drawings shall be submitted before shipment of the equipment to the site.
d.	Review of drawings submitted prior to the final determination of related equipment shall not relieve Subcontractor from supplying systems in full compliance with the specific requirements of the related equipment.
e.	Input/output listings showing point names, numbers, and addresses. Input/output identification numbers from the contract documents shall be cross-referenced in this submittal.
f.	Proposed lesson plans or outlines for all training courses specified herein, including schedule, instructors' qualifications and experience, and recommended prerequisites.

1-4.01.03. Third Stage Submittal. Complete system documentation, in the form of Operation and Maintenance Manuals, shall be submitted before the commencement of field acceptance testing. Operation and Maintenance Manuals shall include complete instruction books for each item of equipment furnished. Where instruction booklets cover more than one specific model or range of device, product data sheets shall be included which indicate the device model number and other special features. A complete set of "as-built" wiring, fabrication, and interconnection drawings shall be included with the manuals. If field-wiring modifications are made after these drawings are submitted, the affected drawings shall be revised and resubmitted. The manuals shall also include software program listings with general descriptions; system schematics; PLC program printouts including ladder logic diagrams, cross-referencing, and address labels; parts lists; adjustment procedures; operation procedures; copy of warranties; and troubleshooting procedures.

1-4.02. Operator's Interface Unit (OIU) Submittals. The OIU consists of a PC, printer, keyboard, color video display, mouse, surge suppression plug-in strip and related hardware and software.

To assist in the review of the OIU hardware and software development, and to gain the early consensus of the Contractor and System Supplier on the developmental approach, the Subcontractor shall make two submittals. The two submittals shall be the conceptual submittal and the detailed submittal.

1-4.02.02 Conceptual Submittal. The conceptual submittal shall be submitted shortly after award of contract. The Contractor shall not proceed with purchasing or installation until receiving approval for conceptual submittal items. Approval or disapproval with comments will be returned to the Contractor within 15 days of conceptual submittal. The conceptual submittal shall consist of the following items as a minimum.

1. Software Development Plan.

The Software Development Plan shall be a listing indicating software with version/revision numbers and a detailed plan of how the Contractor proposes to write any additional software. Details shall include specific commercially-available software that is proposed.

2. Block Diagram-Hardware.

Block diagram shall include equipment catalog numbers, component quantities, cabling information, etc. Diagram shall be complete showing all equipment including networking equipment.

3. Vendor Information Sheets for all hardware.
4. Proposed System Supplier with qualification data. Qualification data shall include name of individuals with a listing of projects which utilized similar equipment and software programs to that being proposed. System Supplier shall be routinely engaged in this type of work for at least the last consecutive five years.

1-4.02.02 Detailed Submittal. The detailed submittal shall be submitted after approval of the conceptual submittal. The Subcontractor shall not proceed until receiving approval for detailed submittal items. Approval or disapproval with comments will be returned to the Subcontractor within 20 days of detailed submittal. The detailed submittal shall consist of the following items as a minimum:

1. Detailed Interconnection Wiring Diagrams for all hardware.  
All equipment shall be shown with communication ports and terminals identified. Cable information shall also be shown as well. Power requirements and connections shall be designated.
2. Vendor Catalog Data Sheets for All Equipment and Components.
3. System Availability Calculations.  
Calculations and/or actual construction data indicating spare I/O, memories, etc. shall be submitted.
4. Documentation of Software.  
Vendor information data sheets indicating revision numbers for commercially available software is required. Complete documentation including program description for any Subcontractor created software shall be submitted.

5. Certification of Equipment Compliance with Environmental Requirements.
6. PLC Program Hardcopy.  
Program information shall include complete annotated ladders, contact cross-referencing, address listings including I/O and any other standard documentation.
7. Customized Graphics Displays.  
Complete drawings representing all displays and additional information required to explain colors, screen actions, etc. shall be submitted.

A system test procedure shall be submitted 10 days prior to commencement of the factory acceptance test. The Subcontractor will receive procedure comments within 10 days of test plan submittal, and shall incorporate all comments prior to commencement of the factory acceptance test.

Operation and Maintenance (O&M) Instructions for the OIU shall be submitted.

1-5. SERVICE. Subcontractor shall show satisfactory evidence that equipment manufacturers maintain a fully equipped service organization capable of furnishing, within 24 hours, adequate inspection and service for this system equipment, including standard replacement parts.

1-6. QUALITY STANDARDS. Materials and equipment furnished shall be new, undamaged, and except for required testing, unused. System Supplier shall be regularly engaged in the business of supplying process monitoring and data acquisition computer systems. The supplier shall have as a minimum 5 years experience in the design, coordination and supply of computer-based monitoring, control, and data acquisition systems.

1-7. SOFTWARE DOCUMENTATION. One complete set of written documentation for each commercially available software program utilized on this project shall be maintained at the project site. Documentation delivery shall coincide with jobsite equipment delivery.

1-8. TRAINING. The System Supplier shall conduct training courses at three levels for

personnel determined by the Subcontractor. Training shall be provided at maintenance, operator, and programmer levels and shall be conducted by personnel employed by the System Supplier familiar with the system supplied and that have experience and training in developing and implementing instructional courses. The System Supplier shall not hire personnel solely for the training required under this section.

The System Supplier shall submit information on the training program for approval 10 days prior to commencement of the first training session. This submittal shall include a course outline, time required, course schedule and instructor information for each level. Training shall be completed after satisfactory site acceptance system testing.

The Subcontractor's pricing shall include, but not be limited to, cost of travel, per diem and manuals for personnel to provide and receive training at the installation location.

1-8.01. Maintenance Training. Training shall be provided for a minimum of two Subcontractor operating personnel at the installation location on routine, preventive and emergency maintenance of all control system components. The training program shall have a duration of at least two days and shall cover at least the following topics.

- Preventive and scheduled maintenance for all equipment.
- Diagnosis of hardware failures.
- Removal and replacement of all spare parts.
- Emergency maintenance and restoration procedures.

One to 2 Contractor personnel may participate in this training. The maintenance training program shall be developed for personnel that have electronics maintenance and repair experience and a general knowledge of computer systems, but shall not assume any familiarity with the specific hardware furnished. Indexed training manuals covering the training subjects shall be provided to each participant. One manual shall be furnished to Contractor personnel.

1-8.02. Operator Training. Training shall be provided for at least two Subcontractor operating personnel at a site in the operation of system hardware and software. The training program shall consist of at least two consecutive working days and shall cover at least the following topics.

- Power-up, bootstrapping and shutdown of all hardware devices.
- Interpretation of all standard displays.
- Appropriate actions for software and hardware error occurrences.
- Use of operator interface displays and keyboards.
- Use of printer including replenishment of supplies.
- Manual data entries.
- Enabling and disabling individual inputs and outputs.

One to 2 Contractor personnel may participate in this training. The operator training program shall be conducted using equipment and software furnished hereunder and shall be developed for personnel with no prior computer experience. Indexed training manuals covering the training subjects shall be provided to each participant. One manual shall be furnished to Contractor personnel.

1-8.03. Programmer Training. Training shall be provided for at least one Subcontractor operating personnel at a site to be determined by the Contractor on the high level applications software. The training program shall consist of at least two consecutive working days and shall cover at least the following topics.

- Loading of any required software into the system.
- Database creation and editing.
- Configuration of printed report and alarm formats.
- Creation and editing of tabular and graphic operator interface display screens.
- Diagnostic routines.

One to 2 Contractor personnel may participate in this training. The programmer training shall be conducted using equipment and software furnished hereunder and shall be developed for personnel with a general familiarity of computer operation and high level application programs, but shall not assume any familiarity with the specific hardware or software furnished. Indexed training manuals covering the training subjects shall be provided to each participant.

1-9. SPARE PARTS. Spare parts and consumable items shall be provided as required.

1-9.01. Packaging. All spare parts shall be delivered to Contractor before final



acceptance of the system. Packaging of spare parts shall provide protection against dust and moisture and shall be suitable for storage. Circuit boards and other electronic parts shall be enclosed in anti-static material. All packages shall be clearly marked with the manufacturer's name, part number or other identification, date of manufacture, and approximate shelf life.

1-9.02. Replacement. Subcontractor may utilize spare parts and supplies during system installation, de-bugging, startup, or training, but shall restore all such materials and supplies to the specified quantities before final acceptance of the systems.

## PART 2 - PRODUCTS

2-1. STANDARD PRODUCT. Materials and equipment shall be standard products of manufacturers regularly engaged in the manufacture of such products and shall essentially duplicate equipment that has been in satisfactory use at least 1 year prior to bid opening.

2-2. PERFORMANCE AND DESIGN REQUIREMENTS. The design of the systems furnished hereunder shall utilize concepts, techniques and features that provide maximum reliability and ease of maintenance and repair. The systems shall include board-level devices such as light emitting diodes or other indicators to facilitate quick diagnosis and repair. Diagnostic software shall be furnished to facilitate system-level troubleshooting.

Where redundant hardware is provided, the system shall be capable of performing all specified functions, without reconfiguring hardware or software, with only one device of each category in service.

2-2.01. Factory Assembly. Equipment shall be shipped completely factory assembled, except where its physical size, arrangement, configuration, or shipping and handling limitations make the shipment of completely assembled units impracticable.

2-2.02. Expandability. The system shall be capable of expansion as required.

2-3. POWER SUPPLY. Unless otherwise specified, power supply to all equipment will be 120 volts, 60 Hz, single phase. Subcontractor shall be responsible for distribution of

power among enclosures, consoles, peripherals, and other components of the system from the power supply receptacles and junction boxes indicated on the drawings. Power distribution hardware shall include cables and branch circuit overcurrent protection installed in accordance with the electrical section.

2-3.01. Facility Distribution System. Equipment not indicated to be powered from an uninterruptible power source shall be suitable for being supplied from the facility distribution system and shall be capable of withstanding voltage variations of  $\pm 10$  percent and harmonics up to the limits of IEEE 519 without affecting operation. Subcontractor shall provide voltage conditioning or filtering equipment if necessary to meet the requirements specified.

2-3.02. Power Supplies. Power supplies for voltages other than those listed above shall be an integral part of the equipment furnished. Internal power supplies shall be regulated, current limiting, and self-protected.

2-3.03. Surge Withstand. All equipment shall meet all surge withstand capability tests as defined in ANSI C37.90 without damage to the equipment.

2-3.04. Uninterruptible Power Supply. As required, an uninterruptible power supply (UPS) shall be furnished hereunder to power the equipment indicated on the drawings or will be furnished under another section. Subcontractor shall be responsible for coordinating the size of the UPS unit with the equipment furnished hereunder, and shall advise Contractor if a unit of higher capacity is necessary.

2-4. SERVICE CONDITIONS AND ENVIRONMENTAL REQUIREMENTS. The equipment provided for the computer control system shall be suitable for the service conditions specified in the attached equipment sections.

All equipment shall be designed and selected to operate without degradation in performance throughout the environmental extremes specified. Equipment shall be designed to prevent the generation of electromagnetic and radio frequency interference and shall be in compliance with FCC Rules and Regulations, Part 15, for Class A computing devices.

2-4.01. Ambient Temperature. All equipment located in non air conditioned indoor areas shall be suitable for an ambient temperature range of 0°C to 50°C and a relative humidity of 10 to 95 percent, noncondensing. All equipment located outdoors shall be suitable for operation in an ambient temperature range 0°C to 60°C and a relative humidity of 5 to 100 percent. Heaters and air conditioning/cooling equipment shall be provided where essential to maintain equipment within its manufacturer-recommended operating ranges.

2-4.02. Deleterious Effects. All system equipment will be installed in areas without anti-static floor construction and without any provisions for control of particulates or corrosive gases. Subcontractor shall furnish any additional air cleaning equipment, anti-static chair pads, or other protective measures necessary for proper operation of the system.

All input/output hardware shall meet or exceed, without false operation, all requirements of NEMA ICS-1-109.60, Electrical Noise Tests.

2-4.03. Noise Level. The equivalent "A" weighted sound level for any system equipment located in the control room, except printers, shall not exceed 35 dBA. The sound level for printers shall not exceed 65 dBA. Sound reduction enclosures shall be provided where necessary to comply with these limits.

2-4.04. Lightning Protection. In addition to other environmental protection specified herein, the entire system shall be provided with lightning protection. Lightning protection measures shall include the following.

2-4.04.01. Grounding. All major components of the system shall have a low resistance ground connection. Grounding system provisions indicated on the drawings shall be modified as recommended by Subcontractor.

2-4.04.02. Surge Arresters. Surge and lightning arresters shall be non-faulting, non-interrupting, and shall protect against line-to-line and line-to-ground surges. Devices shall be solid-state metal oxide varistor (MOV) or silicon junction type, with a response time of less than 50 nanoseconds. Surge protective devices shall be applied for the following:

a.	All power connections to RTUs, PLCs, DCUs, instruments and control room
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	equipment. Surge arresters shall be Transtector "ACP-100 Series", Power Integrity Corporation "ZTA Series", or MCG Surge Protection "400 Series".
b.	All connections to coaxial-based networked equipment (including CCTV, CATV, ethernet, Arcnet, and satellite) where any part of the circuit is outside of the building envelope. Surge arresters shall be Telematic "VP08", Phoenix Contact "TRABTECH C-UFB/CN-UFB Series", Transtector "TCP Series", Northern Technologies "TCS-CP3 Series".
c.	All analog signal circuits where any part of the circuit is outside of the building envelope. Circuits shall be protected at both the transmitter and the control system end of the circuit. Surge protection devices shall not impede or interfere with the use of smart transmitter calibration/communication. Protection devices located near the transmitter shall be Telematic "TP48." Protection devices in control panels shall be Transtector "TSP Series", Telematic "SD Series", or Citel "BP1-24."
d.	All metallic pair (twisted and untwisted) conductor local area network and data highway termination points, where any part of the data highway cable is routed outside of the building envelope. Single-port protective devices shall be Telematic "NP Series" or equivalent.
e.	All serial, PLC data highway, and remote I/O network termination points where any part of the circuit is routed outside of the building envelope. Surge protection devices shall be Transtector "DLP Series" (RS-232); Transtector "FSP4000MC Series" (RS-422); Phoenix Contact "TRABTECH D-UFB" (in-line) or "MT Series" (panel-mount); Citel "E280 Series".
f.	All telephone lines at points of connection to the system. Protection devices for dial-up circuits shall be Transtector "TSJ Series", Telebyte "Model 22PX", Citel "BP1-T", or equal. Protection devices for full period circuits shall be Transtector "LMP Series", Northern Technologies "DLP-S Series", or Circuit Components, Inc. "SPR-TM Series."

**2-5. SYSTEM SOFTWARE CONFIGURATION.** System software shall be configured by the Subcontractor. Configuration services shall consist of the creation of the system database, report formats, operator interface graphic and tabular display screen formats, password and security implementation, and programming of control units to provide a

fully functioning system. The Subcontractor shall fully configure the system using data provided herein or supplied by the Contractor after award of the contract.

The system that is delivered to the field for installation, checkout, and startup shall have all files, or databases, that are configurable in size, be sized in a manner in which there will be a 50% available space available for future work after the completion of this project. This sizing should include the addition of memory modules, disk drives, or any other device to insure the 50% spare space availability. All "tuning" of software that is dependant on space requirements shall be done prior to the completion of this project.

Tuning of software programs shall be accomplished in such a manner that the program operates at its highest performance level. These programs include, but are not limited to Microsoft SQL Server, all PLC ladder logic, and others.

2-5.01. Control System Database. The control system database shall be developed and configured by the Subcontractor. The Subcontractor shall enter information obtainable from the Subcontract Documents into the database prior to soliciting input from the Contractor. The Subcontractor shall determine the need for any "pseudo" database points and shall ascertain and enter all information needed to define these points. The Subcontractor is responsible for entering all information associated with each point. This includes but is not limited to, descriptions, engineering units, associated displays, areas, security, etc. All fields associated with each database point must be completely filled out accurately.

2-5.02. Graphic Screen Displays. The Subcontractor shall be responsible for developing and configuring the custom graphic displays. Each piece of major process equipment that is monitored by the control system shall be displayed on one or more graphic screen. Graphic screens shall be representations of the equipment and piping. The screens must accurately show all devices and equipment that is part of the control loops. These items must be done in accordance to the Configuration Standards and Conventions as described later in this section. The requirement for alarm and/or event displays shall also be provided and proven functional prior to acceptance of the system. A means of capturing and printing of all graphic screens shall also be included. The software program provided must be capable of printing the screen in a black and white (using gray scale) or color format. This program must be accessible from all terminals provided under this contract.

The black and white printing shall be done in a manner in which the use of the black background is not represented in the printout. This is done to keep the utilization of ink cartridge and toner cartridge to a minimum.

The use of pictures taken by digital cameras will be considered as an alternative to custom developed equipment symbols when appropriate. All equipment pictures shall be animated to indicate the current state of the piece of equipment. The following screens shall minimally be provided.

- Main Overview of Plant
- Alarm Summary
- Event Summary
- Overview of each major process area (with vectoring to sub-areas)
- Summary screen to vector to all video trends

2-5.03. Report Formats. Report formats shall be developed and programmed by the Subcontractor using tag names defined in the database creation. Reports shall be provided as summarized below and all listed on the data sheet. All reports will be provided with a header on each page to indicate the contents of each column of information. Each page shall be numbered and indicate the name of the report, the date the report was printed, and the time of the printout. The printout shall also include the time span of the information shown on the report.

- Daily Operating Report. A daily report, listing the major plant variables shall be provided. The report shall include hourly values and minimum/maximum/average values where appropriate.
- Monthly Operating Report. A monthly operating report, which averages the values from the above daily reports, shall be provided. The report shall include monthly minimum/maximum/average values where appropriate.

2-5.04. Configuration Standards and Conventions. A “Software Configuration Standards and Conventions” document shall be prepared and submitted by the Subcontractor. The document shall be submitted for review and approval before software configuration commences. The document shall describe and define such items as proposed graphic display process line colors/representations; color standards for “on”, “off”, “opened”, “closed”, and “alarm” conditions; alarm handling conventions; how items will be selected

for control; methods for navigation between displays; address usage/naming conventions; and security setup. Before submitting the initial draft document, the Subcontractor shall meet with the Contractor to review any of the Contractor's existing standards and conventions. All copies of this submittal shall be provided in color to insure the accuracy of each item. No black and white copies will be accepted. The colors used in the printed submittal shall accurately depict the colors and shapes proposed for use on the final system.

In addition to submitting the document for review, an updated version of the document shall be submitted as part of the O&M Manuals. The document shall be revised to document any additional standards that are established throughout the configuration process.

2-5.05. Configuration Review Meetings. Proposed graphic screens and report formats shall be reviewed with the Contractor throughout the configuration process. The Subcontractor's programming personnel shall attend the initial review meeting. A second review meeting, held at approximately 50 percent completion, but prior to the factory acceptance test, shall also be held. Both meetings shall be held at the Contractor's facilities.

2-5.06. Software Functional Requirements. General functional requirements for system configuration are indicated on the drawings and described in the specifications. The information presented herein and indicated on the drawings illustrates the general functional intent of the system, and may not be sufficient to fully configure the system. The Subcontractor shall be responsible for determining what additional information may be required to complete the configuration tasks, and for obtaining this information from the Contractor.

2-6. SOFTWARE DOCUMENTATION. Subcontractor shall furnish complete documentation on all software supplied with the systems specified herein. Operating systems, compilers, assemblers, and utility and diagnostic programs that are standard commercial products of third parties need not be included in the magnetic media backup. Software documentation shall consist of the following principal items.

a.	One backup set of any integrated circuit or solid-state memory-based plug-in firmware used.
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b.	Two complete back up copies of system and application software in executable format on magnetic media compatible with the system furnished.
c.	Three sets of user reference manuals for all standard system and application software.
d.	One set of user reference manuals for all operating system software.
e.	Three sets of printed as-built reference documentation for any special software provided specifically for this contract.
f.	For each licensed software product, all documentation provided by the product manufacturer shall be provided. This includes all reference manuals and any other documents that were provided by the manufacturer. There should be one set of this documentation for each and every piece of equipment provided. Multiple pieces of similar equipment or software require multiple copies of this documentation.

2-7. SOFTWARE LICENSE. All software programs supplied as a standard part of Subcontractor's products for this project shall be licensed to Contractor for use on the system specified herein. Such license shall not restrict Contractor from using the software on the system provided hereunder or its replacement. Contractor shall have the right to make copies of the software for use on the system provided. Specific requirements of Subcontractor's software license are subject to review and approval by Contractor and Contractor.

2-8. INSTALLATION TEST EQUIPMENT. All necessary testing equipment for calibration and checking of system components shall be provided by Subcontractor. Subcontractor shall also furnish calibration and maintenance records for all testing and calibration equipment used on the site if requested by Contractor.

2-9. NAMEPLATES. Each major component of equipment shall have its identification tag number, manufacturer's name, address, and catalog number on a nameplate securely attached to the equipment in a conspicuous location.

2-10. PROGRAMMABLE LOGIC CONTROLLER (PLC). All equipment for PLC



shall be as described in this section. All equipment, with the exception of enclosures and miscellaneous hardware, shall be the products of a single manufacturer/supplier.

2-10.01. Storage of Electronic Equipment. This equipment shall be stored in accordance with the individual equipment manufacturer's recommendations.

The PLC system shall be shipped completely assembled and wired as practical to minimize reassembly at the site. All finished surfaces and metalwork shall be suitably wrapped or otherwise protected from damage during shipment. Equipment that is shipped separately shall be carefully packed in separate boxes, crates, or cartons as applicable. This equipment shall be marked with the identification of the enclosure in which it is to be installed and fully identified so it can be readily mounted and wired at the site.

2-10.02. PLC Central Processor Module.

- a. General. The Central Processor Module shall contain the memory, processing, timing and scanning circuits necessary for examining the status of the inputs and outputs, addressing the memory, performing integer and floating point mathematics, solving the programmed logic, executing the proper I/O functions and providing PID loop control. The central processor module shall be a Sensaphone SCADA 3000 FGD-3000 or approved equal.
- b. Memory. The processor module shall employ solid state Random Access Memory (RAM) for operation with battery backup. The battery backup shall retain all programmed logic, system definitions, program labels, and user comments with no external source of power applied for at least one month. Battery shall be easily replaceable. Battery level shall be monitored internally as a system diagnostic parameter. A "Battery Low" alarm shall be activated to indicate battery has degraded to a point that no more than two weeks of backup power remain.
- c. Security. The processor module shall be equipped with a controller write protection feature which, when enabled, will prohibit any changes to the programmed logic by any means except a memory failure.

- d. Performance. The processor module shall contain a minimum of 5.1 Mbits of high speed static RAM, and shall be capable of being programmed both directly from a ladder diagram by means of the OIU. Main program firmware shall be stored in 8 Mbits of reprogrammable flash memory. The processor module shall also be capable of being programmed using the C programming language. The processor shall be capable of performing all necessary timing, counting, data comparisons, data transformations, and logical decisions as required for the proper functioning and monitoring of the treatment system. The PLC shall be capable of scanning the entire contents of the memory and executing the programmed instructions in a maximum of 2 milliseconds (ms)/K of memory. The processor module shall be capable of setting outputs to their initial state in the event of an AC power failure and shall restart automatically after power is returned.
- e. Error Detection. The processor module shall be capable of detecting PLC malfunctions, including but not limited to, failure of clock circuits, memory data, decision logic, program counter, and I/O circuits. In the event a malfunction is detected, the processor shall return all affected output circuits to their initial startup status. The PLC shall be equipped with trouble shooting aids in the form of indicator lights to assist in pinpointing malfunctions in the PLC system. In addition, logic shall be programmed to interrogate memory bits associated with PLC internal diagnostics, i.e., low battery. Should a fault be found, the PLC shall transmit a PLC trouble signal to the OIU and cause an alarm in the building and at the Contractor's remote monitoring location.

2-10.03. Coordination. PLC shall be designed and coordinated for proper operation with related equipment and materials furnished by other suppliers under other sections of these specifications. All equipment shall be designed and installed in full conformity with the drawings, specifications, engineering data, instructions and recommendations of the PLC manufacturer; and the related equipment manufacturers.

2-10.03.01. OIU Interface. The PLC shall have provisions for interfacing with the OIU. The PLC shall be equipped with two RS-232 serial communication ports and one RJ11 phone interface. These communication ports shall be integral with the PLC Central

Processor Module. The PLC shall support the transmission of all data and status bits. Each port shall independently support read, write, blockread and blockwrite functions. Blocks shall be considered as continuous sections of memory of any size up to a minimum of 64 registers. Data transmission and reception shall be done in serial fashion at a rate compatible with the OIU equipment. This transmission and reception shall be done over the manufacturer's standard transmission medium.

2-10.03.02. PLC Programming Software. The PLC shall be provided with complimenting programming software compatible with the OIU. This software shall be loaded on the OIU and a second copy of the software furnished to the Contractor for his loading onto a PC at his home office so that Contractor can access / monitor the OIU at his discretion. PLC software shall permit the following tasks as a minimum.

- Upload PLC program from OIU file.
- Download PLC program to OIU file.
- Run PLC program.
- Freeze PLC program.
- Permit PLC programming while PLC on-line.
- Permit PLC programming while graphic screens on-line.
- Initiate PLC diagnostics.
- Force internal registers, internal bits and I/O.
- Provide C, ladder program, and graphical screen editing capabilities.
- Provide means to hardcopy all subprograms such as ladder logic, address definitions, comments, cross-referencing, special functions, loop programs, etc.

PLC process program shall be capable of meeting all requirements described in the process control descriptions included in other specification sections. Control logic shall be done using a ladder, relay-contact format. Ladders shall be annotated with address, synonyms and comments (words) describing the logic. Cross-referencing of contacts to coils shall be available.

2-10.04. Rack Assemblies. All rack assemblies necessary to contain and construct the PLC system shall be provided by the Subcontractor. Each rack shall have plug-in busses and connectors in order to provide data, addressing, power and ground to the devices

installed. Rack assemblies shall be provided as required. The racks shall have a mechanism to securely retain each module installed and prevent accidental removal or disconnection of any installed device.

2-10.05. Input Modules. Input modules shall be provided to handle both analog and digital signals. Modules shall plug into the rack assemblies for connection to the PLC. All external connections shall be made by screw terminals which are on a separable terminal strip to allow disconnection and replacement of a module without removal of any field wiring. Input points shall be provided as required with an additional 50% spare points for each type of input and wired to terminals in the cabinet. The Subcontractor shall coordinate all transient suppression required for inductive loads in accordance with the PLC manufacturer's recommendations. Transient suppression includes, but is not limited to, metal oxide varistors, diodes, and capacitors.

2-10.06. Output Modules. Output modules shall be provided to handle both analog and digital signals. Modules shall plug into the rack assemblies for connection to the PLC. All external connections shall be made by screw terminals which are on a separable terminal strip to allow disconnection and replacement of a module without removal of any field wiring. Output points shall be provided as required with an additional 50% spare points for each type of output and wired to terminals in the cabinet. The Subcontractor shall coordinate all transient suppression required for inductive loads in accordance with the PLC manufacturer's recommendations. Transient suppression includes, but is not limited to, metal oxide varistors, diodes and capacitors. Where required, interposing relays shall be provided and installed between the PLC outputs and control circuits of equipment served if the ampere requirements of the control devices exceed the PLC output rating.

2-10.07. Voice Response Module. A telephone-answering voice response module (VRM) to accept dial in/out requests via the local telephone company, and respond with human-sounding speech to make certain project data available to the operators shall be provided. The VRM shall automatically call designated numbers when certain programmer definable alarm conditions occur. An adjustable 15 minute time period after an alarm occurs shall be programmed to permit an onsite plant operator the opportunity to respond to an alarm before the dialing sequence begins. A brief alarm message shall be provided indicating the system has encountered a an alarm and provide a priority level of

the alarm. Messages shall be modifiable through the OIU. The VRM shall call the first number and upon receiving an operator response shall relay the alarm information via a recorded voice message. If no response is received, then the VRM shall call the second number. The VRM shall be capable of calling at least 16 numbers and repeat the sequence until an operator responds. The VRM shall be programmable to correlate the sequence of dialed numbers with operator's shift times and daily/weekend schedules. The VRM shall have an automatic disconnect at the end of the message. The VRM shall also be capable of providing a verbal alarm status report when queried by an operator. The VRM shall be a Sensaphone, SCADA 3000 FGD-3500 or acceptable equal and shall be compatible with all related PLC modules.

2-10.08. Telephone Modem Module. A telephone-answering modem module to accept dial in/out requests via the local telephone company to make certain project data available to the operators shall be provided. The modem module shall automatically call designated numbers when certain programmer definable alarm conditions occur. An adjustable 15 minute time period after an alarm occurs shall be programmed to permit an onsite plant operator the opportunity to respond to an alarm before the dialing sequence begins. A brief alarm message shall be provided indicating the system has encountered an alarm and provide a priority level of the alarm. Messages shall be modifiable through the OIU. The modem module shall call the programmed primary beeper or fax number first and shall then wait for a response. Alternately, if an e-mail address is listed as the primary contact, the modem module shall send an e-mail to this address and shall then wait for a response. The operator on call should call-in, provide a security code and respond to the message. If no response is received in 10 minutes (adjustable from 1 to 30 minutes), then the modem module shall call a second number (or e-mail the second address). The modem module shall continue down the list until a response is received. The modem module shall be capable of calling at least 16 numbers and repeating the sequence until an operator responds. The modem module shall be programmable to correlate the sequence of dialed numbers with operator's shift times and daily/weekend schedules. The modem module shall be a Sensaphone, SCADA 3000 FGD-3400 or acceptable equal and shall be compatible with all related PLC modules.

2-10.09. DC Power Supplies. The PLC shall be equipped with DC power supply modules operating with input power of 115 VAC " 10%, 60 Hz and capable of supplying the voltage and power levels required by the equipment served. The power supply

modules shall be Sensaphone, SCADA 3000 FGD-3100 and FGD-3200 or acceptable equal and shall be compatible with all related PLC modules.

2-10.09.01. Surge Protection. Each power supply shall suppress all surges up to and including 1000 V peak for up to 500 microseconds, without causing any interruption of the program in progress.

2-10.09.02. Noise Suppression. Each power supply shall comply with NEMA Standard ICS, Section ICS 3-304.42, Electrical Noise Tolerance.

2-10.09.03. Power Loss Ride Through. Each power supply shall be capable of enduring a minimum duration of 16 ms of AC power loss with no effect on the output voltage or power levels.

2-10.09.04. Overcurrent Protection. Each power supply shall be provided with a thermal trip circuit breaker properly sized to provide overcurrent protection.

2-10.10. Cabinet. All PLC components except for voice response module (VRM) equipment shall be contained in one cabinet. The cabinet shall comply with NEMA Standard ICS, Part IC 6-110. Enclosure shall be NEMA 12 with white enamel inside color and gray exterior color. The cabinet shall be constructed in accordance with the manufacturer's standards, subject to approval by the Contractor. Cabinet shall be self-supporting with proper stiffness and support.

The Subcontractor shall notify the Contractor 10 days prior to completion of the cabinet. At its option, the Contractor may inspect the cabinet. If any cabinet fails any inspection, the Subcontractor shall make any necessary changes and adjustments at no additional cost, and notify the Contractor when ready for re-inspection. No equipment shall be installed in the cabinets until the completion of these inspections.

2-10.11. Support Equipment.

2-10.11.01. EMI/RFI Resistance. Each component of the PLC shall be capable of resisting interference in conformance with NEMA Standard ICS, Section ICS 3-304.42, Electrical Noise Tolerance.

2-10.11.02. Miscellaneous Hardware. The PLC system shall be furnished with all interconnecting cable, connector and hardware to supply a complete, operational, structurally stable system.

2-11. OPERATOR'S INTERFACE UNIT (OIU). The OIU serves as the interface between the groundwater treatment system operating personnel and the PLC. This section is divided into two major sections, Hardware and Software.

2-11.01. Hardware. The hardware section covers the furnishing and installation of the OIU and support equipment for monitoring, control, and operation of the groundwater treatment system. The major hardware shall include, but not be limited to, the following principal items.

- One PC consisting of a central processing unit, main memory, video memory, sound card, and magnetic media mass storage devices. Acceptable manufacturers include Dell, Gateway, Hewlett-Packard or equivalent.
- One color video display system.
- One printer with a printer stand for hard copy output, alarms, and reports.
- Keyboard, mouse and other input devices as required by the software.
- Surge suppression plug-in strip.
- Industrial speed modem.
- All support equipment required to insure a complete and functional system.

The Subcontractor shall also furnish all of the necessary interconnecting cables, accessories, and appurtenances required for proper operation of the OIU. All major components of the computer (central processing unit, video display, keyboard, memory cards, etc.) shall be of the same equipment supplier. If any departures from these specifications are deemed necessary by the System Supplier, details of such departures and the reasons shall be submitted in writing to the Contractor for review with or before the Conceptual Submittal. No such departures shall be made without written approval.

Equipment shall be shipped completely factory assembled, except where the physical size, arrangement, or configuration of the equipment, or shipping and handling

limitations make the shipment of completely assembled units impractical.

The system shall, as a minimum, be expandable to provide the following capabilities.

- Additional hard disk capacity for the OIU.
- Three slots in the PC shall be available for adding interface cards.
- Replacement of graphic displays with higher resolution units.

2-11.01.01. Power Supply. Unless otherwise specified, power supply to all equipment shall be 120 volts, 60 Hz., unregulated single phase. The System Supplier shall be responsible for distribution of power between cabinets, consoles, peripherals, and other components of the system. Power distribution hardware shall include cables and branch circuit overcurrent protection installed in accordance with Section 16050.

All power supplies to obtain voltages required by the System Supplier's equipment other than those provided above shall be an integral part of the equipment furnished. Internal power supplies shall be regulated, current-limiting, and self-protected.

All equipment furnished shall be capable of tolerating and operating through a power interruption of 8 milliseconds or less without interruption of normal operation.

All power supplies shall be designed to prevent the generation of surges into the power source during normal operation.

2-11.01.02. Environmental Requirements. All OIU equipment shall be designed and selected to operate without degradation in performance throughout the environmental extremes specified herein. Equipment shall be designed to prevent the generation of electromagnetic and radio frequency interference and shall be in compliance with FCC rules and Regulations, Part 15, for Class A computing devices.

2-11.01.03. Cables. The system shall be furnished with all power cords and interconnecting data communication cables required for the proper operation of the system.

All power cord connected equipment shall be furnished with a minimum of 6 feet 3-wire



grounded cord and plug assemblies.

Cables for transmission of digital signals and data between components of the system shall be provided as required.

Cables for keyboards shall be flexible and self-coiling, and at least 6 feet in length.

2-11.01.04. Central Processing Unit (CPU). Central processor shall be an Intel Pentium III or Pentium IV microprocessor with a clock speed of not less than 1500 MHz.

A real time clock and calendar shall be provided with a battery back-up. The clock shall be accurate to one minute per month. The calendar shall properly adjust the date for leap years and turn of the century.

2-11.01.05. PLC Communication. An interface card (modem) shall be provided for OIU communication with the PLC and Contractor's home office PC. The interface card modem shall plug into one of the expansion slots of the OIU and shall have an assignable communication port number. The modem shall be capable of transmitting and receiving voice and data communications at a minimum of 33.6 Kbps. The modem shall be a Diamond SupraExpress Speakerphone or approved equivalent.

2-11.01.06. Main Memory. The OIU shall be provided with at least 128 MB of RAM with access time of 70 ns or less.

2-11.01.07. Video Memory. The OIU shall be provided with at least 4 MB of video RAM with access time of 70 ns or less.

2-11.01.08. Sound Card. The OIU shall be provided with a 16-bit sound card. The sound card shall plug into one of the expansion slots of the OIU. The sound card shall be a Creative Labs SoundBlaster or approved equivalent.

2-11.01.09. Mass Memory and Off-Line Storage. The on-line mass memory system for the OIU shall include not less than one hard disk and controller. The hard disk drive shall be used to store all system software, database information and all run-time data including graphic display screen formats, report formats and the most recent process data. Hard disk drive capacity shall be not less than 20 gigabytes. Automatic read-after-write

checking shall be provided.

The drive shall have an access time of 35 milliseconds or less, and shall park the heads on an unused area of the disk when the unit loses power. One removable, internal, 1.44 megabytes, 3.5 inch floppy disk drive and controller shall be furnished. One removable, internal tape backup unit with 2 sets of tapes complete with all data and programming files (does not include application software) shall be furnished. In addition, 2 more blank tapes shall be provided to store historical process data records. One CD-ROM (16X or greater) using industry standard formats shall be provided for the purpose of downloading program applications, etc.

The OIU shall include sufficient on-line mass memory to meet the maximum operating requirements of the system and shall include 100 percent spare, unused capacity. The unused capacity shall be completely free and available for future use at the time of final acceptance.

The mass memory system supplied with the OIU shall be expandable beyond that delivered with the system. It shall be possible to double the provided mass memory storage capabilities without requiring software modifications.

Each mass memory system shall incorporate parity or error detecting code generation and checking. Detected errors shall be either automatically corrected or reported by the hardware for software action.

2-11.01.10. Color Video Display System. One color video display shall be suitable for desk mounting and capable of VGA high resolution. The video interface card shall operate properly with the video display screen, and provide graphics output with individual pixel (picture element or dot on the screen) addressability as well as text output capability. Each pixel shall meet the adjacent pixel. Local controls shall be provided with each cathode ray tube (CRT) display for contrast, brightness, tint, and focus. These controls shall be easily accessible to the operator. Radiation emission shall comply with the existing standard requirements. Noninterlace resolution shall be 1280 x 1024 pixels with a minimum refresh rate of 60 hertz vertical (70 hertz for 1024 x 768 operation) and dot pitch of .28 mm. The screen shall be coated with a permanent non-glare coating or be treated to permanently reduce glare from the surface of the screen.

Minimum monitor viewable screen size shall be not less than 9 inches high by 13 inches wide.

2-11.01.11. Keyboard. The keyboard shall include an enhanced typewriter arrangement of alphanumeric symbols, vertical and horizontal tab keys, a standard numeric pad, separate cursor direction controls with a home key, and function push-button keys.

The keyboard shall meet the following minimum requirements, or acceptable equal.

Key feedback	Audible or tactile feedback on each key stroke
Key error control	2-Key, 3-Key, or N-Key roll over
Key size	0.5 inch diameter, nominal
Key spacing	0.75 inch centers
Key pressure	0.9 to 5.3 ounce
Key travel	0.05 to 0.2 inch

Cursor controls shall be provided through the following cursor control keys.

Home  
Left  
Right  
Up  
Down  
Tab

The Tab pushbutton shall only move the cursor to a predefined position in each poke point field.

2-11.01.12. Printer. Subcontractor shall provide one general purpose inkjet printer. The printer shall be utilized to provide hardcopies of alarms, events and reports.

2-11.01.12.01. Inkjet Printer. Printer shall meet the following minimum requirements:

Print Density 600 dots per inch.

Printer Output 6 pages per minute printing black text at 600 dpi and 4 pages per minute color printing at 300 dpi.

Paper Feed Continuous single pages.

Acceptable manufacturers include Canon, Hewlett-Packard, or equivalent.

2-11.01.13. Uninterruptible Power Supply (UPS). The Subcontractor shall provide a single UPS in free-standing, floor mounted, tower-type enclosure containing the following:

- a. Rectifier/Battery Charger
- b. DC Battery
- c. Inverter
- d. Dynamic Bypass Switch

2-11.01.13.01. Electrical Ratings. UPS ratings shall meet or exceed the following:

Input

- a. Voltage: 240/120 VAC, single phase, +10%/-15% (240)
- b. Frequency: 60 Hz +/- 5%
- c. Noise Suppression: Common Mode 100 dB, Normal Mode 60 dB
- d. Surge Suppression: IEEE C62.41, Category A3

Output

- a. Power: As required plus 50% spare capacity.
- b. Voltage: 240/120 VAC, single phase, +/- 3% (no-load to full-load)
- c. Frequency: 60 Hz +/- 0.5 Hz. (free-run)
- d. Load Power Factor Range: 0.5 lagging to 0.5 leading
- e. Wave Shape: Sine wave with max. 5% total harmonic distortion, full non-linear load.
- f. Environmental: 0 degree to 35 degree C (operation temperature), 0 to 95% non-condensing relative humidity.
- g. Transfer Time: Uninterrupted

Operation

The primary source shall power the rectifier/battery charger, which shall supply sufficient DC power to simultaneously operate the inverter at full load and charge the battery. The critical load shall be connected to the inverter through a dynamic bypass switch. The critical load shall be supplied normally from the inverter. If the primary source fails, the battery shall furnish DC power to the inverter to maintain the load on clean, rectified and inverted AC power. If the inverter fails, the dynamic bypass switch shall instantaneously transfer the load to the bypass source. Also, in the event of an overload or fault, the load shall be transferred to the bypass source to clear the fault or overload and protect the inverter. When the fault or overload condition is cleared, the inverter shall be automatically switched back into service again, all without interrupting power to the load.

#### Rectifier/Battery Charger

The rectifier/battery charger shall be a solid state unit sized to simultaneously provide continuous power for the critical load and power to charge the battery.

#### Battery

The battery shall consist of enclosed maintenance-free, lead-acid, sealed battery cells. The battery shall be sized to provide power for 15 minutes during full load.

#### Inverter

The inverter shall be solid state unit providing clean, regulated 240/120 VAC power to the critical load.

#### Dynamic Bypass Switch

The dynamic bypass switch shall monitor the inverter output, transfer to bypass, and automatically retransfer to the inverter as specified without interrupting the critical load. The unit must have the ability to manually transfer to and from dynamic bypass.

#### Control and Monitoring

The UPS shall be microprocessor controlled and furnished with a front control panel containing a selectable variable display and alarm lights. The battery time remaining, based on the actual load, shall be automatically displayed when the input power fails. Abnormal UPS conditions such as warnings and alarms shall be combined into one alarm and inputted to the PLC to cause a general UPS alarm.

### Power Distribution (UPS to Critical Loads)

Unless otherwise noted, power supply to all equipment shall be 120 volts, 60 Hz., single phase. The UPS shall power all control system equipment.

2-11.02. Software. All operator interactive software shall be menu driven and shall request input from the operator in question and answer or fill in the blank type forms. Menus shall present all of the choices available to the operator at the point in the program along with a brief description of each menu choice. Question and answer or fill in the blank request shall be displayed with a range of acceptable operator responses when possible.

System level software shall include a real-time operating system, a calendar/time program, a file management program, and a system of diagnostic routines in addition to any compilers, editors, loaders, or assemblers required to support the process control software language. Contractor's copy of software will not permit Contractor to make operational changes to the OIU or PLC. Rather, Contractor's copy will enable Contractor to monitor all system operations and readily download data upon command.

2-11.02.01. Source Code. The Subcontractor shall provide one complete "as shipped" listing of the source code for all OIU customized software.

2-11.02.02. Executable Code. Operation of the OIU system shall not require that software and/or data reside on removable media during the operation of the system.

The back-up copies of all (nonremovable) hard disk resident software and data shall be shipped with the system on separate loadable magnetic media (3-1/2 inch diskettes) or CD-ROM disks.

The Subcontractor shall provide two separate copies of all utility programs and diagnostic programs for the OIU on loadable magnetic media (3-1/2 inch diskettes) or on CD-ROM disks, one copy each for use and archive.

All magnetic and CD-ROM media shall be labeled as to its content, revision and generation date.

2-11.02.03. Compiler. All custom software shall be written in "C" or Pascal computer language. The System Supplier shall choose one for all custom software to be written.

2-11.02.04. Executive Software. The operating system shall support main memory resident programs in a real-time multiprocessing environment. The operating system shall be event driven and shall be able to process several resident programs concurrently.

The operating system software shall provide the following minimum functions.

- Respond to demands for services from a program request or an operator command.
- Allocate the resources available in the system. These resources shall include: main memory usage, computation time, peripheral usage, and I/O channel usage.
- Assign system resources on the basis of a sufficient number of task priority levels such that a logical allocation of resources and suitable response times are assured.
- Delay servicing a request if one or more of the computer system resources required is not immediately available, queuing them in order of priority, and informing the program requesting the resource of the availability or failure of the resource.
- Resolve contending requests in accordance with priority. If a new request is of higher priority than the previous request to which the contended resources have already been allocated, an orderly reallocation shall occur and the resources shall be assigned to the higher priority request.
- Service requests for execution of one program by another.
- Transfer data between programs in response to a proper request.
- Temporarily inhibit the executive software's capability of program interruption in order to allow safe execution of programs sensitive to interruption.
- Manage and command all information transfers to and from peripheral devices.

2-11.02.05. Program Execution. Program execution shall be scheduled on a priority basis. A multilevel priority interrupt structure is required. A program interrupted by a higher priority program shall be entered into a list of pending programs and its execution

shall be resumed once it becomes the currently highest priority program. Initiation of programs shall, as a minimum, be activated in the following ways.

- In response to external interrupts.
- At a scheduled time of the day.
- On an elapsed time interval basis.
- On request by another program.
- On request from the man-machine interface.

The system shall allow periodic programs to be scheduled. The allocation of resources to a time scheduled program shall be based on its relative priority and the availability of computer system resources. Priority of software shall be defined as follows.

- Communication Software.
- Alarm Annunciation Software.
- Operator Control Software.
- Operator Graphics Interface Software.
- Database Software.
- System Editing Software.

2-11.02.05.01. Calendar/Time Program. The calendar/time program shall update the second, minute, hour, day, month, and year in the operating system and make accurate time and date information available to all system level and application software. Variations in the number of days in each month and in leap years shall be handled automatically by the program. The operator shall be able to set or correct the time and date from the operator interface display and keyboard.

2-11.02.05.02. File Management Program. The file management program shall provide programmer interactive file management capabilities for on-line and off-line storage. All files shall be accessed by symbolic names. The file management system shall maintain information on each file in MS-DOS format indicating its name, location, physical size, date and time of creation, and date and time of last reference.

Off-line file management shall allow the operator to effectively use removable media as a convenient long-term storage and I/O device. It shall provide the ability to create files,



search for a designated file, or erase a file. The software shall allow removable media to serve as a backup to the primary mass media drive as required by the operator. Mass real-time data storage shall normally be accomplished by the fixed media unit and shall not be the function of the removable media drive unit.

It shall be possible to duplicate any mass storage file onto removable media diskettes.

2-11.02.05.03. Diagnostics. Diagnostic programs shall be furnished with the software package to detect and isolate hardware problems and assist maintenance personnel in identifying causes for system failures. The computer manufacturer's standard diagnostic routines shall be used as much as possible. Diagnostic software and test programs shall be furnished for each significant component in the system.

2-11.02.05.04. Password Protection. Operator access within the system shall be controlled with a password protection scheme. Password protection scheme shall only allow access to specified users based on ID and passwords. After initial creation, passwords shall be field alterable by the user assigned to the password.

2-11.02.05.05. Startup and Restart. Software shall be provided which initializes and brings the computer from an inactive condition to a state of operation readiness with graphic screens on-line.

Initialization shall include performance of complete diagnostics prior to startup, initializing operating system software, and initializing application software. Initialization shall also include the loading of all memory resident software, initializing timers, counter and queues, and initializing all dynamic database values.

2-11.02.05.06. Shutdown. The software shall provide an orderly shutdown capability for shutdowns subsequent to a manually entered shutdown command. When a shutdown occurs, in response to a command or a malfunction, the software shall control the affected hardware quickly and automatically to a secure state. The software shall save computer system parameters and other information which would be useful for an audit trail of the equipment status prior to shutdown.

A hardware Dead-Man-Timer (DMT) shall be provided for the computer. The computer

shall reset its DMT to prevent it from timing out. If the computer is inoperable due to any failure, the DMT shall generate an alarm.

2-11.02.05.07. Software System Response Characteristics. All responses to the operator shall be clear and complete. Every operator request shall generate a response within two seconds which indicates that the request has either been completed, is being processed, or cannot be performed. Every request must generate a response, even if it is a negative one.

The software shall input each operator command, decode it, and then check its validity and correctness in the sequence of data and controls previously presented from that station.

All invalid requests shall be rejected before any transmission is made to I/O hardware for control. Whenever the checks are not passed, the software shall respond to the last operator command with an "Invalid Command" message, indicating why it was unable to proceed. When an invalid command is signaled, the software shall clear all pending input from keyboard and not initiate any system control commands.

Any new display shall update the video display within 2 seconds after being requested by an operator command.

All calculated and real-time variables shall be updated on the video display at least every 2 seconds.

#### 2-11.02.06. Operator Graphics Interface Software.

2-11.02.06.01. Alphanumeric. Static and dynamic alphanumeric information shall be able to be displayed in normal or reverse video and in at least 3 character sizes. Dynamic alphanumeric displays linked to discrete signals shall change color or blink in correspondence to the status or alarm condition of its variable. Dynamic alphanumeric displays linked to analog signals shall display the current numeric value of the variable and variable setpoints, scaled as specified in the database and engineering units. Graphics software shall be configured to read calculated variables from the OIU's math co-processor and PLC and plot them every 5 seconds.

2-11.02.06.02. Graphic Symbols. Graphic symbols display software shall include standard symbols as specified below and allow generation of at least 30 user-defined custom symbols. All symbols shall be capable of being rotated to at least eight different positions in 45 degree increments utilizing the math co-processor.

Standard graphic symbols shall consist of standard ISA representations of process equipment such as pumps, valves, flowmeters, motors and other equipment.

All graphic symbols shall be easily placed anywhere in the display and shall be able to be defined as dynamic and linked with a process variable.

2-11.02.06.03. Standard Displays. The graphics software shall include at least the following standard non-configurable displays:

- a. Current Alarm Summary. Processing and reporting of defined alarm events and conditions shall be accomplished within 2 seconds. Alarm messages shall be presented in an organized, unambiguous, clear and convenient manner to operators and maintenance personnel.

Alarm messages shall indicate the date and time when the alarm was detected by the OIU (not the time of alarm message printout) to the nearest second, the device in alarm and descriptive information. Alarm messages for the OIU and communication malfunction alarms shall list the date, time and description of the alarms.

The alarm summary display shall be a chronological listing of the alarm messages, beginning with the most recent alarm. The display shall clearly indicate whether an alarm is acknowledged but still present or unacknowledged. Acknowledged alarms shall be automatically removed from all displays after returning to a normal condition.

Alarm summary shall be printed in 24 hour cycles and stored in a Plant Master Logbook for maintenance and audit trail purposes. Alarms shall be multiplied and transmitted to an automatic dialing alarm monitor (auto dialer) as specified.

2-11.02.06.04. Customized Graphic Screen Displays. Individual graphic screens shall be

configured to show facility processes as follows. Additional graphic screen information to be displayed is described in the process control description included with other specification sections.

1. The groundwater treatment plant shall be displayed on a graphics screen showing the extraction well, all building outlines, tanks and major equipment items along with identifier tags. The plant operator shall access second tier or specific graphics screens by using the mouse or keyboard to pick a point on this overall screen. The overall screen shall be accessible from any of the second tier screens as well.
2. Analog input signals displayed shall include the continuously updated process signal. This information shall be displayed on the graphics screen adjacent to the equipment outline.

All analog flow inputs to the control system shall be totaled. The Contractor's System Supplier shall program the ladder logic to automatically totalize all flow inputs and to automatically zero out totalizer registers at an operator selectable interval. The plant operator shall also be able to zero out all flow registers by manually overriding the automatic function from the operator's keyboard. All flow totals shall be displayed on the graphics screens.

Digital signals shall be displayed on the same graphics screens as the analog signals for associated equipment. Digital input displays shall change color on digital input toggle. A "Not Operating" equipment status shall display on a solid green background, while "Operating" status shall display on a solid red background.

All alarm conditions shall flash on a red background. Information shall be grouped by process subsystems and subsystem screens shall be referenced to each other.

2-11.02.06.05. Database. The database shall consist of two parts, the real time database and the static database.

The real-time database shall include those dynamic variables which change with time or conditions including all digital and analog inputs.

The static database shall include those fixed parameters and constraints which define the characteristics of the system such as alarm limits, start/stop times, point name, and sensor span. The static database shall reside in the hard disk system for the OIU. The static database shall be updated automatically whenever a change to the static database is entered into the system.

2-11.02.06.06. Historical Data Storage. The system shall have the capability to process all real-time data and to store selected values in a database format. It shall be possible to store scanned values on a periodic basis, a maximum value which occurred within a given time or a calculated value. It shall be possible to generate reports using the historical database processor.

Historical records shall be maintained in on-line files before being transferred to removable storage media. System software shall automatically store and summarize on-line files without requiring operator intervention, and shall also prompt the operator to enable the transfer of historical data to removable media. The data shall be stored in a form that allows historical reports to be readily prepared from the magnetic media.

Equipment run times shall be configured to return to zero hours after reaching 10,000 hours. In addition, the plant operator shall be able to zero out all run-time registers from the operator's keyboard.

2-11.02.07. System Editing.

2-11.02.07.01. Control Editor. The control program editor shall enable the operator to add, modify and delete menu options on the control screen. Controlling parameters such as, but not limited to limits, scaling factors and time delays shall be editable items in this editor.

The use of fill-in-the-blank displays for editing is desired.

2-11.02.07.02. Database and Report Editor. The database editor shall enable the

operator to add, modify and delete data. Data may include information automatically recorded by the OIU, or information entered by the operator.

The report editor shall enable the operator to create, modify, and delete reports generated from the database. Selection of the following parameters for each report shall be possible:

- Data to appear on the report consisting of measured variables, calculated variables, and manually entered data.
- Start and end time of data to be included in the report.
- Print format for each variable.
- Titles and subtitles to appear on each page of the report.
- Paper width from 8 to 14 inches.
- Print pitch from 10 to 16.5 characters per inch.
- Number of columns on each page.
- Number of lines per page and number of pages per report.
- Scheduled periodicity of the report for printing.

The use of fill-in-the-blank displays for editing is desired.

2-11.02.07.03. Graphics Editor. The graphics display editor shall enable the operator to create, modify, and delete video displays.

System data shall be linked to the graphics display via system ID tags.

2-11.02.08 Office Software. The PC shall be provided with software application programs permitting the operator to perform word-processing and generate spreadsheets and data bases. Programs shall be Microsoft Office (or acceptable equivalent) and of the latest version.

2-11.03. Storage of Electronic Equipment. This equipment shall be stored in accordance with the individual equipment manufacturer's recommendations.

2-11.04. Coordination. OIU shall be designed and coordinated for proper operation with related equipment and materials furnished by other suppliers under other sections of these

specifications. All equipment shall be designed and installed in full conformity with the drawings, specifications, engineering data, instructions and recommendations of the OIU manufacturer, and the related equipment manufacturers.

Related equipment and materials can include, but will not be limited to, interface to programmable logic controller, conduit, and cable.

### PART 3 - EXECUTION.

3-1. ASSEMBLY. All racks shall be fully installed before delivery, and rack spacing shall conform to the manufacturer's recommended spacing. The PLC system shall be completely wired at the factory, with the exception of field wiring and wiring between cabinets. Splices shall not be accepted in internal enclosure wiring.

3-2. INSTALLATION. All internal wiring shall be neatly and carefully installed in plastic wire ducts. Each wire shall be plainly marked at each end to facilitate future maintenance. No more than 2 conductors shall be terminated on the same terminal screw, unless otherwise noted.

3-3. TERMINATIONS. Internal wiring shall be terminated by means of approved pressure grip (solderless) lugs of the indented barrel type on all terminals except those not capable of accepting pressure grip lugs. The barrel of the lugs shall be indented into the conductor using a tool especially designed for the purpose. Ring tongue indented terminals, equal to Burndy Type YAE or YAV, T&B STA-KON or approved equal, shall be used on all wire terminations unless specified otherwise on the drawings.

3-4. TERMINAL BLOCKS. All internal wiring shall be terminated at terminal blocks plainly lettered or numbered. Terminal blocks shall be molded or fabricated type with barriers rated not less than 600 volts. Terminal blocks shall be high density, style H, #22-12 AWG, tubular screw type with pressure plate and as manufactured by Allen-Bradley or approved equal. The Subcontractor shall provide 20% spare terminal blocks unless otherwise noted.

3-5. CLEARANCE. Sufficient clearance shall be provided for all leads and lead identification. All leads for external circuit wiring shall be connected to grouped terminal

blocks located for convenient connection of external circuits.

3-6. CONDUCTORS. Unless specified otherwise in these specifications or on the drawings, all wire used in control system cabinets shall be Class B, stranded copper, 14 AWG or larger.

3-7. FUSE BLOCKS. Fuse blocks shall be provided as required or indicated on the drawings. Location within the cabinet shall permit easy fuse replacement. Fuses shall be provided and installed in fuse blocks. 100% spare fuses shall be provided at final acceptance. Rail mounted fuse blocks are not acceptable.

3-8. SOFTWARE PROGRAMMING. All software programming shall be completed by the System Supplier prior to delivery of the control system equipment. Any necessary debugging shall be performed at the installation site prior to the final adjustments and acceptance tests.

3-9. PROCESS CONTROL LOGIC. The Subcontractor shall program the control system to control and monitor the groundwater extraction well, groundwater treatment process system and treatment plant facility in accordance with the process control system descriptions included with other sections of the specifications.

3-10. GENERAL. Normal operation of the facility shall be with all control devices in "auto" providing operation without operator attendance. The facility shall also have the capability to be operated in "manual" ("hand") mode by plant operators. Manual mode shall be selectable by plant operators at each piece of equipment.

"Hand" position of selector switches shall bypass PLC control and energize motor starters if all other interlocks, if present, are satisfied. "Hand" is intended to be for maintenance only and performed by qualified personnel.

Instrumentation setpoints are relative only and shall be modified as required by equipment manufacturers and Contractor to provide a complete operational system.

Subcontractor shall establish reset values or apply programming functions for alarm actuation and control points to prevent cyclic or nuisance conditions.



3-11. PLANT ALARM LOGIC. All treatment plant alarm annunciation shall be through the control system. Packaged equipment audible annunciation shall not be provided and is not acceptable. Should equipment be provided with local audible annunciation, the Subcontractor shall disable it.

3-12. VOICE RESPONSE MODULE. VRM shall be used to alert responsive personnel via a standard telephone line of abnormal conditions at the un-manned groundwater treatment facility.

3-12.01. Dialer Actuation. The following abnormal conditions shall actuate dialing with an appropriate pre-recorded message given. Examples of the messages are also shown. All alarm messages shall include the name of the facility location (i.e., Electra, Westside, etc.) where the alarm has occurred. Process alarms which shutdown the process (in whole or in part) shall be communicated via the VRM. Other alarms to be transmitted shall be determined by the Subcontractor.

- Loss of electrical service power. Message - "(Location) Treatment plant power failure."
- Recovery well conductivity probe low-low. Message - "(Location) Recovery well level low-low, well shut down."
- Plant sump level high-high. Message - "(Location) Plant sump level high-high, respond immediately."
- Influent holding tank level high-high. Message - "(Location) Influent holding tank level high-high, well shutdown."
- Influent holding tank level low-low. Message - "(Location) Influent holding tank level low-low, process shutdown."
- Influent bag filter pressure high. Message - "(Location) Influent bag filter pressure high, process shutdown."
- Potassium permanganate tank liquid level low-low. Message - "(Location) Potassium permanganate level low-low, process shutdown."
- Chemical tank level low-low. Message - "(Location) Sequestering agent level low-low, pump shutdown."
- Air stripper pressure low-low. Message - "(Location) Air stripper pressure low-low, check blower, process shutdown."
- Air stripper level high-high. Message - "(Location) Air stripper liquid level

- high-high, process shutdown."
- Air stripper level low-low. Message - "(Location) Air stripper liquid level low-low, process shutdown."
- Air stripper effluent bag filter pressure high. Message - "(Location) Air stripper bag filter pressure high."
- Vapor phase granular activated carbon unit differential pressure high. Message - "(Location) Vapor phase granular activated carbon unit (number) differential pressure high."
- Liquid phase granular activated carbon unit differential pressure high. Message - "(Location) Liquid phase granular activated carbon unit (number) differential pressure high."
- Effluent tank level high-high. Message - "(Location) Effluent tank level high-high, process shutdown."
- Effluent tank level low-low. Message - "(Location) Effluent tank level low-low, effluent pump shutdown."
- Plant PLC halted. Message - "(Location) Plant PLC halted, respond immediately."
- Plant fire alarm. Message - "(Location) Plant fire, take immediate action."
- General alarms (possibly prioritized). Message - "(Location) General abnormal condition(s) exist."

3-13. PLC ALARM. Programmable Logic Controller shall monitor its internal diagnostic functions. Should these diagnostics detect a failure, (I/O module communication failure, etc.) or pending failure (low battery voltage, etc.), the control system shall cause an alarm. An alarm shall be given if the PLC is halted by internal diagnostics.

3-14. SYSTEMS CHECK. As required, Subcontractor shall provide the services of a field manager and a trained and experienced field supervisor to assist the installation contractor during installation, and to calibrate, test, and advise others of the procedures for installation, adjustment, and operation.

3-14.01. Field Manager. As required, Subcontractor shall appoint a field services manager who shall be responsible for the coordination of all system check-out and startup activities, and who shall be immediately available to Contractor by phone or on site for

the duration of this project.

3-14.02. Field Inspection at Delivery. As required, the field supervisor shall inspect major equipment items within five working days of delivery, to assure that the equipment was not damaged during shipment and shall supervise or assist with unpacking, initial placement, and initial wiring of the system.

3-14.03. Training for Installation Personnel. As required, the field supervisor shall train the installation personnel in reading and understanding submittal drawings, and in the correct installation and wiring procedures for the equipment.

3-14.04. Field Inspection Prior to Start Up. After installation and wiring connections are complete, the field supervisor, with additional Subcontractor's personnel for the number of days as required, shall verify that each external connection to the system is correctly wired and field process components and devices are functioning as intended.

3-14.04.01. Analog Signals. Analog input signals shall be simulated at the transmitting source, and verified to be received at the proper register address in the control system. Analog outputs shall be generated at the control system, and verified to be received with the correct polarity, at the respective receiving device.

3-14.04.02. Discrete Signals. Discrete input and output signals shall be simulated and verified that they are received at the respective receiving device, and at the proper voltage.

3-14.04.03. Devices by Other Suppliers. If interrelated devices furnished by other suppliers or under other contracts, such as valve actuators, motor controls, chemical feeders, and instruments, do not perform properly at the time of system checkout, the field supervisor shall use suitable test equipment to introduce simulated signals to and/or measure signals from these devices to locate the sources of trouble or malfunction.

3-14.04.04. System Check Out Report. The Subcontractor shall submit a written report on the results of such tests to Contractor. Additional documentation shall be furnished as requested by Contractor to establish responsibility for corrective measures. Subcontractor shall verify, in writing, to Contractor that Subcontractor has successfully completed the external connection check before beginning system startup or field acceptance testing.

3-14.05. Start Up Assistance. After the field supervisor has completed the system check and submitted his report, Subcontractor shall supply a factory-trained engineer and a programmer to provide on site start up assistance for the number of days as required. During the startup period, these personnel shall thoroughly check all equipment, correct any deficiencies, and verify the proper operation of all components.

3-15. TESTING. The system shall be subject to factory and field site acceptance testing. The test procedures shall be submitted as part of the detailed submittal.

The System Supplier shall prepare a system test procedure to be approved by the Contractor which shall demonstrate conformance of the system to this section of the specifications. The test shall be performed by the System Supplier and witnessed by representatives to be designated by the Government.

3-15.01. Factory Acceptance Testing. After the control system is assembled and debugged at the System Supplier's facility, a successful factory acceptance test shall be performed before the system is shipped to the jobsite. It shall not be necessary to supply identical external I/O hardware, however, selected I/O functions representative of all types of I/O shall be simulated. The Subcontractor shall also furnish all interface hardware and software necessary for factory acceptance testing purposes.

The complete system including all peripherals and associated software shall be completely factory tested under simulated operating conditions. Normal operating sequences and alarm conditions shall be simulated during the testing. The results shall be noted on the video display and logging printer for hard copy. The testing procedures for hardware and software shall follow the requirements listed below and shall be forty-eight (48) hours in duration without system faults of any kind.

3-15.02. Hardware Test. The control system, and all hardware associated or interfaced to the system shall be tested by the System Supplier at one location. The factory test set-up shall include inputs from the keyboard, mouse and PLC, and shall demonstrate the correct simultaneous performance of all peripherals.

3-15.03. Software Test. Software tests shall include running of all diagnostics, all

debugging routines, and all system test routines. The operating system, advanced process control language compiler, control programs, and all associated drivers shall be fully tested and operable for the system test. No software "patches" or changes will be allowed to bypass failed or flawed modules during the test.

3-15.04. Site Acceptance Testing. After installation of the system and checkout by the System Suppliers personnel, a site acceptance test shall be performed. The test shall be performed by the System Supplier and witnessed by the Contractor. The System Supplier shall notify the Contractor in writing at least 14 days prior to the proposed date of the test. Subcontractor shall furnish a copy of the test and checkout plan for approval 20 days prior to testing. Each test shall be described and tabulated for approval sign-off by the Contractor.

The site acceptance test shall consist of the factory acceptance testing procedure and an additional five consecutive days during which the system shall run continuously without loss of basic functions. Failure of any component in the judgement of the Contractor shall cause the acceptance test to be terminated and re-started at no additional cost.

3-15.05. Calibration. The Subcontractor shall be responsible for installing field I/O devices providing the proper setpoint and calibration requirements to coordinate with the control system. Setpoints shown are for reference and may be modified as required for a complete operational system. The Subcontractor shall provide certified calibration data sheets for each external I/O device. Calibration data sheets shall indicate date; device tag name; calibration tester manufacturer, model number and last date of tester calibration; signal input and output at 0, 50 and 100 percent for analog instruments; range and setpoint settings; and calibration personnel's name. All calibration data sheets shall be bound in a binder with adequate identification and indexing. This binder shall be given to the Contractor.

End of Section